Using the AquaMap System at a Study Site

U.S. Department of the Interior
U.S. Geological Survey
Florida Caribbean Science Center

U.S. Department of the Interior
National Park Service
Virgin Islands National Park

Using the AquaMap System at a Study Site

Prepared by:

Jeff Miller
National Park Service
Virgin Islands National Park
St. John, USVI

June 2002

~~~~~~

One of a series of monitoring protocols prepared for the Florida Caribbean Science Center
under the auspices of the Caribbean Field Station, St. John, USVI

U.S. Department of the Interior
U.S. Geological Survey
~~~~~~

Acknowledgements

We'd like to acknowledge and thank the many people that helped bring this protocol alive: Rich Aronson, Elena Astilleros, Winnie Batch, Ed Beaty, Don Catanzaro, Ries Collier, Marcia Creary, Bob Dorazio, Steve Hertzberg, Dennis Hubbard, Karla Hubbard, Marco Flagg, Maryann Franke, Nick Funicelli, Ginger Garrison, Andy Goldstein, Walt Jaap, Judy Lang, Ellen Link, Dulcie Linton, Steve Miller, Thad Murdock, Matt Patterson, Jim Petterson, Brendalee Phillips, Laura Plaut, Kaf Smith, William Stelzer, Rob Waara, Leslie Walling, and Jeremy Woodley.

USING AQUAMAP AT A STUDY SITE

I. Overview

II. System Preparations

Goal: to have a knowledge of the physical characteristics (i.e., habitat, boundaries, depths, etc) of the potential study site.

1. Aerial photos
2. Snorkeling
3. Preliminary dives
4. Previous reports

By the end of this you should know if this is a site you want to study.

Goal: this is what needs to be done before using the equipment in the field.

1. Charge the diver and baseline stations
2. Attach flotation collars and connecting lines
3. Configure the stations
   — Load the proper operating system in stations
   — Load the proper configuration file in stations
4. Prepare the diver station
5. Install “dummy” plugs after charging
6. Consult checklist to evaluate need for lines, floats, etc.

By the end of this section you should be ready to use the system in the field.

III. AquaMap Basics

Goal: this section will tell you how to deploy the baseline stations and suggestions on where to deploy them.

1. General information
2. Station deep or shallow?
3. Transducer up or down?
4. Suggestions on where to locate the stations around the site.

By the end of this section you will know how to deploy the baseline stations and have suggestions on where to deploy them around your study site.

By the end of this section you will know how to set up and conduct the range/ noise tests, and how to evaluate and apply the results.

B. Initial Tracking

Goal: This section will define and describe how to conduct an initial baseline survey, evaluate the placement of the baseline stations, and define and describe how to perform an initial perimeter recording.

By the end of this section, you will know how to conduct an initial baseline survey, track around the area evaluating the SONAR signal quality, make a perimeter recording and evaluate those results to help in the determination of the final position of the baseline stations. This section is repeated until you are satisfied with the quality of SONAR signal you are receiving and you have marked the positions of the baseline stations.

C. The Definitive Baseline Survey

Goal: this section will describe how to perform, the definitive baseline survey, evaluate and enter the result into the configuration file. It will also describe how to perform the definitive perimeter trace.

By the end of this section you will be able conduct a definitive baseline survey, and obtain and use the results to conduct the definitive perimeter trace.

D. Navigating to Waypoints

Goal: this section will describe AquaMap system preparations and techniques to navigate to sample points for the first time.

By the end of this section you will know how to track to and find waypoints that have been loaded into the diver station.

I. Overview

AquaMap™ is similar in concept to the Global Position System (GPS), except that it operates underwater, on a much smaller scale, and uses a SONAR (sound navigation and ranging) system to emit and receive high frequency sound. Although light and most radio waves travel more slowly and shorter distances in water than in air, sound propagates significantly faster and much further in water, and is therefore used in fish finders and depth sounders, as well as by marine mammals to navigate and communicate.

When using AquaMap to fix a position, the diver station emits a signal that is received by two or three baseline stations at established locations which then send a signal back to the diver station. The diver station uses the defined locations of the baseline stations and the time it takes to receive each return signal to calculate its own location. To use this system to navigate accurately and relocate the same points over time, each baseline station must be returned each time at exactly the same depth and location, and the diver station must have the correct information regarding their positions.

We use the AquaMap system to:

- map the perimeter of a study,
- calculate the site area in square meters,
- define the population of sample points within that site,
- randomly select a number of points from that population, and then
- locate those points during initial and subsequent surveys.

A. *Materials and Equipment*

(in addition to standard dive equipment)

- AquaMap hardware
  - 1 diver station with SONAR transducer, magnetic pointer, battery charger with power cord, and two dummy plugs (to seal ports while not in use)
  - 3 baseline stations, each with a dummy plug, battery charger with power cord, and a flotation collar with associated nuts, bolts, and washers
  - Data exchange cables and connector adapters for connecting the AquaMap components to your PC
- Computer software
- AquaMap applications (SmartDive and DT-test) and utilities (DiveTerm and Convert)
  - Microsoft Excel
  - AREA plug-in or program
- Miscellaneous underwater equipment
  - Compass
  - Narwhal to hold the diver station and transducer
  - Rope
  - Miscellaneous floats, pins, sand screws
  - Lift bags, if needed to add positive buoyancy to the baseline stations in order to stabilize them in the current

B. *System Components*

Our use of AquaMap requires three baseline stations that are deployed at the study site and one mobile diver station.

- **The baseline stations** are cylinders that house batteries, electrical circuitry, and a transducer (the end of the baseline station or cable from which the SONAR pulse is released and received).
- **The diver station** is a hand-held device used to compute positions relative to the baseline stations. Unlike GPS devices, which indicate location using latitude and longitude, the “fixes” computed by the diver station are “Waypoints” in an X:Y coordinate system referenced to the location of the baseline stations. However, baseline station positions can be marked using GPS. So that you can create a site map and relocate selected Waypoints, the diver station’s features include position recording (tracing your track) and storage of Waypoint coordinates. The diver station keypad is operated by using a magnetic pointer. For details about diver station features, see the AquaMap Operators Manual, and DiveTracker Users Manual.

Throughout this protocol, these icons are used:

Signifies activities generally done on land, and usually requiring a computer.

Signifies activities done at the study site, mostly underwater.

Indicates a specific step in carrying out the protocol.

Tips to keep you on track.

Precautions to help safeguard your life, your equipment, or your data.

C. *Summary of AquaMap Protocol and Time Requirements*

Procedure	In the Office	In the Field
System preparations *(~ 2-4 hours)*	• Charge station batteries • Create and download the configuration file when applicable • Plan where you'll locate the baseline stations	
Range and noise tests *(1 or possibly 2 dives; total time ~1 day)*	• Set up DT-test on diver and baseline stations	• Conduct the range and noise tests
	• Evaluate the test results	
Initial baseline survey and perimeter recording *(2 dives are best)*		• Determine baseline compass bearing • Conduct initial baseline survey • Trace and record site perimeter
Evaluating recorded data *(~2-4 hours)*	• Download and convert data from the diver station • View the data as a graph • Estimate the size of your study site • Review raw range recording	
		If necessary based on results of tracking and recording, adjust placement of baseline stations. This will require repeating the initial baseline survey and perimeter recording.
Definitive baseline survey *(1 dive plus 1 hour pre-dive and 1-2 hours post-dive)*		• Permanently benchmark the locations of the baseline stations • Collect the baseline survey data
	• Download and convert the data • Determine the baseline ranges • Edit and reload configuration file	
Definitive perimeter tracing *(1 dive plus 1-2 office hours)*		• Conduct the definitive tracing of the site perimeter
	• Download and convert the data • Edit and reload configuration file	
Defining Waypoints and transects *(1-3 hours)*	• Identify a population of sampling points in the site and order them randomly • Select a sample of random points that will define your transects and create a path to connect them • Load path into the diver station	

II. System Preparations

A. *Site Reconnaissance*

The establishment of a long term monitoring site should be done only after a thorough evaluation of the site, and possible comparison with other candidate sites. Using tools such as aerial photos, maps, charts, and any previous reports you should become familiar with the general orientation of your potential study site. This may involve general observation snorkel trips or dives at the site so that you can define your study area in terms of:

- general layout;
- orientation (to compass headings or land based-features);
- habitat type(s);
- approximate size;
- features for delineating boundaries, e.g., depth gradients, sloping fore reef, sand channels, rocky outcroppings; and
- potential hazards as a work site, e.g., in ship channel.

This process can take days to weeks, with the result being a site that you have chosen based on knowledge and information, both historical and actual field data.

B. *System Readiness*

In addition to familiarizing yourself with how to use the DiveTracker software you've installed on your PC, there are many steps to get through before you can begin using AquaMap to locate sample points on your study site. However, before you go into the field to use the equipment, you'll need to do the following.

1. Charge the station batteries.

Before diving, you'll need to charge the diver station and the three baseline stations. The diver station window will show a charging graph. When charging is complete, the message "DONE" will appear. On the baseline stations, the indicator light patterns will show whether the units are charging or fully charged.

When you connect the diver station to charge, observe the graph in the display window and keep track of how long the charge is taking and the voltage level when it is complete. The displayed information will accurately reflect the charging level after about one minute, and updates are displayed every 15 seconds.

If the battery charge does not reach 12 volts in 90 minutes, consider the following:

- If it takes 45 minutes to reach 12 volts, the battery may not have been low when charging began. Consider charging the battery again. If it does the same, assume the station is fully charged. However, if you're certain the battery was low and it still shows fully charged in much less than 90 minutes, consider replacing the battery. (Send it back to the company.) The batteries will need to be replaced about every three years, depending on storage temperature, use, number of charging cycles, etc.
- If the charge time was 90 minutes, and the voltage = 10 or 11, it may be a false full charge reading. Sometimes the voltage "curve" flattens out, simulating a

fully charged battery. Consider re-starting the charge. You may see a shorter charge time since you are starting with a partially charged battery, but the voltage should reach 12.

- If the charge time was < 10 minutes and the voltage reading is “Temp Trig,” this indicates the Temperature Trigger has been activated. Consider this a system error, and re-charge the station.

The baseline stations must be using the SmartDive application to be charged.

There is no way to monitor battery strength in the baseline station. If you’ve been running the DT-test (page 15) and the battery gets too low, you may not be able to connect the station to the computer in order to switch to the SmartDive application. The light flash patterns are similar, so you may not be certain which program is running. If the station will not initialize and proceed to the flash pattern after you’ve attempted to charge it, the problem may be that it was in the DT-test application. Therefore, you should reattach the baseline stations to the computer and switch to SmartDive as soon as possible after you’re through with the DT-test so the battery can be charged.

If you cannot initiate the charge program on either the diver or the baseline stations you may need to use a three-way adapter plug that will enable you to connect the stations to an outside power source while they are connected to your PC. This will permit you to load the SmartDive application, thus allowing the battery-charging program to run.

2. Attach flotation collars and connecting lines.

Fasten a flotation collar snugly around each baseline station. To ensure that the same baseline station is deployed at the same location for each dive, each station should be labeled (BS1, BS2, BS3) and have a matching label on its collar.

These syntactic foam collars provide enough flotation for installation in low-surge, low-current conditions, but in surgy waters, you may find it necessary to add a liftbag or other flotation device to stabilize the baseline station in the water column. To facilitate this, weave a small, strong line through the flotation collar bolts that can fasten the lifting device.

3. Configure the stations.

Run the appropriate operating system on the diver and baseline stations.

- SmartDive for normal tracking
- DT-test for the Range and Noise tests

Load the right configuration file (see page 11).

4. Prepare the diver station.

Install the diver station into the Narwhal. Connect the mobile transducer to the diver station so that it can communicate with the baseline stations.

Make sure you have the magnetic pointer that operates the diver station and keep a spare one in your BCD pocket.

5. **Install plugs to protect the communications ports from salt water.**

After charging and configuring the diver and baseline stations, make sure that the data exchange ports have each been sealed with a dummy plug. These ports are used only when connecting the stations to your PC. The connections are watertight to a depth of >100m, but saltwater will corrode the internal connections, causing errors in signal transmission. Since there's generally no reason to take the diver station underwater without its transducer, that dummy plug may never actually be used underwater. However, it's a good idea to use it while the diver station is out of water and doesn't need to be connected to the transducer.

6. **Check your equipment list.**

Especially while you're getting used to this system, we recommend making a list so that you can check that you have the equipment necessary for your field work. Such a list is not included here, as it will vary among sites. See "Materials and Equipment," page 1.

III. AquaMap Basics

A. *Deploying the Baseline Stations*

1. General Information

- **Station buoyancy**. With its flotation collar, each baseline station is ~7 lbs. positively buoyant in salt water, so temporary holding devices (e.g., weight belts or concrete blocks) are needed during the initial stages of mapping and tracking. Lay the weights carefully on the bottom so as not to harm any fragile component. Later on, sand screws or pins can be installed to more permanently mark where the baseline stations are to be located, and lines can be cut and/or spliced to use at a specific site (see page 24).
- **Finding the baseline stations.** To make sure that divers who are not carrying the diver station can easily find the baseline stations, run a fiberglass measuring tape between them. This is especially helpful in the early stages of site set-up, but can be used throughout tracking.
- **Unobstructed signal path.** The signal path from the diver and baseline station transducer is similar to the light emitted by a street lamp in that the energy is radiated down and away from the transducer. The baseline stations need clear signal paths to each other and the diver station.
  - Make sure that terrain features such as boulders or a sloping sea floor do not obstruct the signal path.
  - Any fastener, clip, knot, float, excess line, tie wrap, lift bag, or marine growth on submerged lines and floats may interfere with signal transmission.
  - Currents, surge, and wave action can loosen objects that are not securely fastened and cause problems during tracking. Do not take the chance that a "tucked in" line will remain so during the entire day of tracking.
  - You must take the same precautions in regard to the attachment of the float to the diver station transducer.

2. **Baseline station depth.**

   For best results, the baseline stations should be at least 2m above the sea floor and no less than 2m below the surface. They should not be so shallow as to be severely affected by wave energy or endangered by boat traffic. They are generally deployed at ~3m. Reels, tapes, and/or lines may be used to raise the stations to the right depth. Brass or stainless clips can be tied to the transducer cage to simplify attachment to lines, reels, or tapes. But at some shallow sites, SONAR communication is better if the stations are positioned near the bottom.

3. **Transducer up or down?**

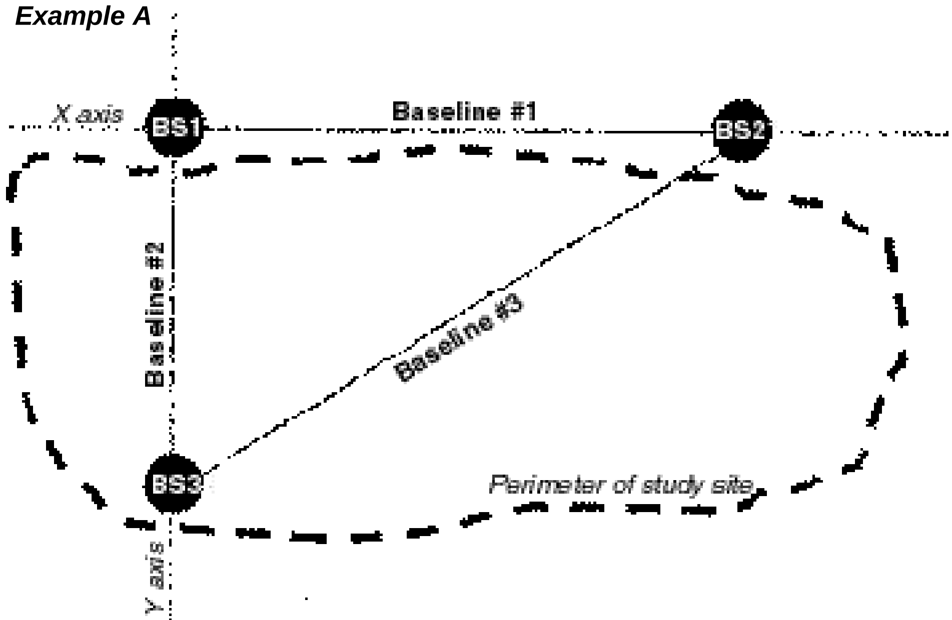
   When the baseline stations are placed near the surface, the transducer is generally positioned pointing down. When the baseline station is placed near the bottom, the transducer is generally placed pointing up, but experiment to see what works best at your site.

4. **Where to locate the baseline stations.**

   Using maps, charts, photographs and/or notes taken while conducting reconnaissance snorkels or dives, make a pre-dive approximation of the best places to put the baseline stations in or around the study site. As shown in Example A, the line connecting Baseline Stations 1 and 2 is referred to as Baseline #1; it will correspond to the X-axis on a plotted graph of your site. Here are some points to keep in mind.

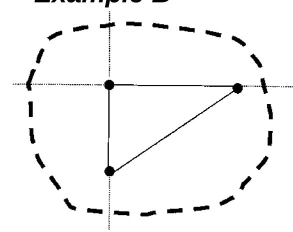
   - When you are positioned at Station 1 and facing Station 2, Station 3 must be located to the your right.
   - We have found that an L-shaped arrangement like that shown in Example A, with the three stations placed near the perimeter of the site, often works well. When Station 3 forms a 90° angle with Stations 1 and 2, Baseline #2 will correspond to the negative Y-axis on a plotted graph of your site.

Example A



- You may find it best to orient Baseline #1 on the long axis of the site, if there is one, and slightly beyond the site perimeter. For example, if the deep side of the site boundary is a forereef slope to a sandy plain, Stations 1 and 2 could be positioned 10m to 15m from the forereef slope in the sandy plain. This will permit better sonar signal reception when tracking along the forereef slope.
- However, other arrangements may also work, depending on the particular characteristics of your site. As shown in Example B, it is possible to set up the baseline stations so that all four quadrants on the X and Y axes can be tracked in, or so that none of the baseline stations are located within the study area.

Example B



- AquaMap works best if the baseline stations are 50m to 150m apart, and no closer than 30m.
- Signals from only two baseline stations are needed to "fix" a position with the diver station. However, if the system has been configured for three baseline stations, then AquaMap has to receive signals from all three stations in order to determine which two baseline stations provide the best geometry for calculating the position; the signal from the third station is then used to determine which side of the baseline for the fix. You therefore need to arrange the stations so that at any point within the study site, the maximum distance from the diver station to the farthest baseline station is within the operational range established by the TX-test.

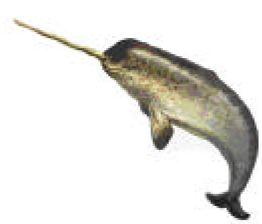
B. *Avoiding SONAR Communication Troubles*

1. Sound waves vs. air spaces.

The AquaMap SONAR signals do not travel effectively through air spaces. As re-breathers are impractical and exhalation bubbles will always be present, they may reduce SONAR communication by blocking the signals or creating noise that causes interference. We attempt to calibrate for this noise by performing the range and noise tests (page 15), but other steps can be taken to minimize bubble trouble.

2. Avoiding exhalation bubbles.

Our tests have shown that signal reception improves more than 50% if we can keep the diver station transducer out of the exhalation bubble stream. Desert Star, the developers of AquaMap, suggest having the diver station transducer cord travel behind the tank and through a BDC fastener clamp that is held buoyant above you by a small peanut-type float, but this places the transducer in or near the bubble stream. Instead, we have developed a holder to securely cradle the diver station and position the transducer, allowing flexibility in different environments. Because of its resemblance to the long-tusked Arctic whale, we call the holder "the Narwhal."



3. Avoiding other blockages.

With the Narwhal, the diver station transducer can be hard-mounted in the end of a PVC pipe or suspended by a peanut float. In either case, it is positioned about 0.5m in front of the diver's body and exhaled bubbles. The diver must remain aware of the transducer location so that other objects, divers, or reef features do not block the sonar signal. To keep the transducer vertical, attach a peanut-type float to the top of the frame around the transducer.

C. *Baseline Configuration Data*

To use the AquaMap system to relocate precisely the same points underwater over time, you need to:

- position the baseline stations in exactly the same place (location and depth) each time; and
- load the diver station with a configuration file that contains accurate data about where the stations are located.

To obtain this baseline configuration data, you need to determine four aspects of the baseline stations' positions.

Baseline configuration component	How it is determined	Page
• Bearing of baseline 1 (the line from BS1 to BS2)	Measured by divers with a compass achieving accuracy within 5º-10º of actual bearing.	20
• Depth of each baseline station • Length/range of each baseline	Measured by the stations during in-water tests (baseline surveys).	20
• Angle between baselines 1 and 2 (the line from BS1 to BS3)	Automatically during initial baseline survey. Manually when you evaluate the baseline survey data.	20 26

D. *The Configuration File*

1. Introduction

To use AquaMap to navigate accurately and relocate the same points over time, each baseline station must be returned to exactly the same depth and location each time, and the diver station must have the correct information regarding their positions. This information is provided by software, referred to as a configuration file, that is downloaded into each station. The configuration file defines the operational parameters and working environment during AquaMap use at a particular site and tells the diver station and the baseline stations how to communicate with each other. Later on, you can also store the Waypoints used for data sampling in the configuration file.

You will need to keep a metadata file log (a "readme" text file) in a central location that lists the names and storage locations of all the files that you create. Make written notes of the names of all files used such as configuration, Waypoint, recordings, and converted files. Trying to remember which file contains which information can be difficult after you've moved on to another site.

As listed in the following table, the user is responsible for entering and editing 10 key components of this file. You create an initial configuration file after completing the range and noise tests at your study site. As you gain more information about the site and the location of your baseline stations, you will need to go back and edit this file and reload it into the stations. Once you have created an initial configuration file, you may also edit that file for use at another study site in a similar environment rather than create a new file from scratch.

2. Contents and Recommended Settings

Configuration file component	How it is determined	Page
• The number of baseline stations being used • The number of mobile stations being used • If any surface stations are being used • The water temperature	Depends on your study site and which AquaMap equipment you're using	1
• Threshold for background noise levels	Derived from range and noise tests	15
• The baseline configuration	Entered automatically into the diver station during initial test dives Entered manually after the definitive baseline survey	19 26
• Automatic Gain Control operation • Length of RMS error queue • Data to be recorded during observation recordings	Standard settings that are used in all configuration files	40 40 41
• A data file containing Waypoint coordinates	After doing the definitive baseline survey and perimeter recording	45

3. Create and/or edit the configuration file.

You can either create a new configuration file or modify an existing one by editing it. When you create or edit a configuration file, you can choose from two options:

- With the *simple* create or edit, the settings and values used in the configuration file are determined for you based on your answers to some general questions about the study site.
- With the *advanced* create or edit, you enter the settings and values into the configuration file yourself.

The advanced mode includes more setting options, but we suggest you use it because it seems to produce more reliable results than does the simple mode. In both modes, any settings that you do not specify are left at the default setting if you are creating a file, or at whatever the prior setting was if you are editing a file. **The default and recommended settings are shown in Appendix A.**

On your PC, go to START and choose: PROGRAMS DIVETRACKER DIVETERM.

A message will appear: "No link, please reset station." Ignore this. The diver station does not have to be attached to your PC in order for you to create or edit a configuration file.

You will need to set DiveTerm to use metric units. Go to FILE OPTIONS and select USE METRIC UNITS.

Go to the FILE drop-down menu and choose CREATE A CONFIGURATION FILE or EDIT A CONFIGURATION FILE, and then ADVANCED or SIMPLE, depending on what you need to do. If you are editing an existing file, open it in the Select Configuration File window.

As shown in Appendix A, you will pass through five screens for ADVANCED CREATE or ADVANCED EDIT (three for SIMPLE), but you need to concern yourself with only some of the settings at this point. The table above lists some of the more common entries you may need to check. Click on NEXT when you are ready to go to the next screen.

When you are at the last configuration screen click on OK if you are satisfied with your choices. If not, choose BACK to return to a previous screen and change what needs changing.

When you click on OK, you will be prompted to save the file with a name and location. Use a name (with a *.par extension) that corresponds to the site where you will be tracking and the default file location, then click on SAVE.

4. Download the configuration file to the diver and baseline stations.

After the configuration file has been saved, you need to download it into the diver and baseline stations.

Make sure the diver station is not powered on (= OFF).

Connect the diver station to your PC using the gray data exchange cable (a gender adapter may be necessary) and the adapter connector.

Open DiveTerm on your PC (if it isn't open yet) and turn on the diver station.

Within a few seconds, you should see a message on your PC that the link has been established. If you do not, turn off the station, close DiveTerm, and start over.

When a link has been established, click on RUN (the small button on the lower left side of the display). When the application window appears, choose SMTDIVE (the most recent version, if more than one is listed). Pause to allow SmartDive to load (5-10 seconds).

> When SmartDive loads, it automatically tests the SONAR communication. Since the stations do not operate well in air, the message TEST FAIL will appear, followed by some numbers and binary code. That's okay, and you can proceed with these steps.

When the Terminal window appears, go to the COMMAND drop-down menu and choose CONFIGURE STATION.

When the Location window is displayed, select the appropriate configuration file and click on OPEN.

When the Download Configuration File window appears, select the station that's connected to your PC and choose DOWNLOAD. A numeric display will show the progress of the download.

If you get an error message or the scrolling numbers indicate no progress, close DiveTerm and turn off the station. Re-launch DiveTerm and, when it is open, turn on the diver station and repeat the steps above.

When the download to a station is complete, first disconnect the station and then turn it off. Do *not* choose DONE on your PC until you have configured all of the stations.

After the configuration file had been downloaded to the diver station, you will be prompted to download the file to BS1. After making sure it is turned off, connect BS1 to your PC using the data exchange cable and connector adapter.

Turn on BS1 and repeat the downloading procedure for it and the other baseline stations. Although the diver station displays a message that a link has been established, with the baseline stations you will need to watch the flash patterns. When you see one rapid flash per second (this may take about a minute), the link has been established.

Check the label on the baseline station to make sure that you're downloading the configuration file to the station selected in the display window. If you select BS2 from the display window when you have BS3 connected to the computer and you then position BS3 in the BS3 site position, you would be unable to track successfully.

When all of the stations have been configured, choose DONE. Turn off the last station and insert dummy plugs into all the cable connection ports.

E. *Recording Data at the Site*

The digital data generated by the diver station at your study site can be saved as either of two types of recordings.

1. Definitions.

- ***Position recordings*** are used to make a continuous recording of sequential positions, e.g., to trace the perimeter of a study site or the line of a transect. They are also serve as a diagnostic tool for assessing SONAR signal effectiveness. You press F4 once from within the precision navigation screen, and the diver station will record every signal to and from the diver station position until you press F4 again or the memory is full (after 60 to 90 minutes, depending on how frequently position fixes are received).
- ***Observation recordings*** are made at specific points, such as at the transect origin and terminus. Before the dive, you use the configuration file to define which data are to be recorded, and this recording will be made each time you press F3 from within the precision navigation screen. If you want to relocate a point later on, this is the most accurate way to save the position. The RMS error is also displayed and recorded, so you know the accuracy and precision of the location where the observation was made.

2. Download the recorded data.

You need to download the position and observation data from the diver station as “record” files (*.rec) in order to view them on your PC and make room on the diver station for other recordings.

Connect the diver station to your PC and go to DIVETERM.

Turn on the diver station.

When a link has been established, go to RUN SMTDIVE.

When the terminal window appears, go to the COMMAND drop-down menu and choose READ “TAPE” MEMORY (SMARTDIVE/MICROTRACK).

When the Select File window is displayed, select a name and location for the record file. We recommend using the default location.

Click on SAVE. A percent display will indicate the progress of the data download.

When the download is complete, turn off the diver station, disconnect it from the computer, and close DiveTerm.

3. Modify the configuration file to record observations.

Within the configuration file is an option that allows for default data to be recorded as observation recordings. Put a check mark next to that option in the Edit Diver Observation Records section of the Config-5 screen of Advanced Edit/Create. See Appendix A for more details.

4. Delete the recording.

Depending on how frequently position fixes are received, the diver station memory will eventually fill up. For example, if fixes are received once per second, the memory will be full in about two hours (SmartDive refers to it as a “tape.”) After you have downloaded the file to a PC, you can erase the tape so that it can be filled again. To do this:

Press the MODE button on the diver station to call up the main menu.

Use the 0/ key to move to select ERASE TAPE.

Press ENTER to execute the erasure.

F. *The Convert™ Program*

1. Definition and use.

Convert is the program that modifies recorded data into a useable format. It will convert both position and observation recordings relative to either:

- Raw Auto-position (distance from the diver station to each baseline station), or
- X and Y Auto-position (location of the diver station relative to the X and Y axes).

You need to know what you want to do with the data before you convert it. Common examples are:

- Position recording (initial or definitive perimeter) for graphic display: save **for import**, converted with respect to **X and Y** axes.
- Position recording for evaluating SONAR communication effectiveness: saved **for import**, convert with respect to **raw** ranges.
- Observation recordings for graphic display: saved **for import**, converted with respect to **X and Y** axes.
- Observation recordings for written report: saved **as text**, converted with respect to **X and Y** axes.

Since Convert displays locations and ranges, it needs to know the baseline configuration that existed when the recording was made. Therefore, when converting a recording, you will have to know and have on your computer's hard-drive the configuration file that was used during the recording.

2. File management.

When the data has been converted, a split window will appear, with the observation data displayed in the top portion of the window, and the position data in the lower portion. Which type of file is created (and what data are displayed) from those recordings depends on which settings you select for the conversion program. (See Appendix B for setting details.)

Observation recordings = *.rec file
Converted observation recordings saved as text = *.obs file
Converted observation recordings saved for import = *.dbi file

Position recordings = *.rec file
Converted position recording saved as text = *.dat file
Converted position recording saved for import = *.dbi file

3. How to use convert.

The detailed instructions for CONVERT are found in Appendix B.

G. *The AREA Program*

1. Definition.

Desert Star programmer Andy Goldstein wrote the AREA program for the purpose of displaying a sample area and creating sample waypoints within that display. Since it displays the points recorded in a perimeter trace, it can also be used to visually evaluate the effectiveness of SONAR communications. For example, major gaps in the perimeter trace would represent a loss of or blocked signal.

2. Features.

The AREA program will calculate the size of the displayed area, plot the total number of sample points, randomize those points, find the best path through the points, and save them as a waypoint file (*.wpt) for easy loading into the diver stations.

3. How to use the AREA program.

Detailed instructions for this program are found in Appendix C.

IV. Using AquaMap in the Field

There are five major activities in which AquaMap is used in the field.

- **Range and noise tests.**
  - The Range test helps you determine how far apart you can position the baseline stations and how large an area you can "map" as a perimeter.
  - The Noise test provides data about the ambient noise level in your study site so that you can enter the "threshold" value into the configuration file.

  See section A, page 15.

- **Initial tracking.** During this activity, sonar communications and placement of the baseline stations are evaluated by:
  - Positioning the baseline stations
  - Measuring the bearing between B1 and B2.
  - Performing an initial baseline configuration *in situ*.
  - Performing an initial perimeter recording/trace.
  - Downloading the recordings for analysis.

  You have completed this activity when you have determined permanent locations for the baseline stations. See section B, page 19.

- **Definitive baseline survey.** To acoustically measure the distance between the baseline stations, you make a position recording at each station. This recording is downloaded into a PC and brought into a spreadsheet for analysis. Eventually the data are used to modify the configuration file, which is downloaded into the diver and baseline stations. Then the definitive perimeter recording is made to provide the tracing that will be used to identify the sample population and select random points. See section C, page 25.

- **Navigating to Waypoints.** This involves tracking through the site using only the AquaMap system to locate sample points for the first time that you identified by the AREA program. See section D, page 32.

- **Relocating sample points.** This involves:
  - Locating the correct configuration file on your computer hard drive,
  - Downloading it into the diver and baseline stations,
  - Deploying the baseline stations at the right depth and orientation, and
  - Tracking to the original sample points using the AquaMap system, possibly using laminated photos taken at the site on a prior occasion.

  See section E, page 35.

A. *The Range and Noise Tests*

Our experience has shown effective tracking within a 200-meter range. However, the propagation of SONAR signals at a given site may be affected by a combination of bay configurations, biological noise, bubble interference, and substrate composition, and may vary from day to day. When selecting a study site, you will therefore need to determine the effective operational range of AquaMap within the area and consider the site's acoustical qualities. For the range test, you use the diver station to measure the signal strength from a baseline station over a known distance, which means measuring how far from the baseline station its pulse can be "heard" by the diver station. For the noise test, you turn off the baseline station and use the diver station to measure the ambient noise of the study area.

To do this, download DT-test from your PC to one of the baseline stations (set up to transmit continuously) and to the diver station (set up to receive). DT-test is a software program that contains the operational commands for both the range/transmit (TX) and noise (RX) tests. The more locations within your study site at which you perform these tests, the better your model of signal propagation characteristics will be. But spending even one dive to conduct a range test along a transect and collect noise data at 10 to 15 points will provide a fairly accurate estimate of AquaMap's operational range in a given locale.

1. Set up the diver station.

Connect the diver station to the serial port of your PC via the gray data exchange cable and the connector adapter.

After you've made sure the diver station is turned off, on your PC, go to START and choose: PROGRAMS DIVETRACKER DIVETERM.

When DiveTerm is open, touch the magnetic pointer to the small indentation on the left lateral side of the diver station to turn it on.

When a link is established, in the DiveTerm window choose: RUN DT-TEST.

If a link is not established, shut down DiveTerm, turn off the diver station, then reboot both.

Press #6 on the diver station keypad or your PC keypad to select the RECEIVE function. This station will now be listening for the signal from the transmitting baseline station.

You can adjust the gain and the frequency by using the magnetic pointer on the diver station function keys.

- The gain controls the amplification of SONAR signals. Pressing F1 will change the gain sequentially through four settings (0,1,2,3). Each increase in gain doubles the sensitivity (see "gain" in the glossary in Appendix D). Use the Gain 2 setting for the noise test.
- Pressing F2 will change the frequency in units of 1 kHz. The frequency should be the same as that of the baseline station (29 kHz).

2. Set up the baseline station.

Connect the gray data exchange cable to the serial port of your PC (a gender adapter may be necessary).

Connect the other end of the cable to the appropriate connector adapter (8-pin, box end) and attach the adapter to one of the baseline stations.

On your PC, go to START and choose: PROGRAMS DIVETRACKER DIVETERM.

When DiveTerm is open, turn the baseline station on by rotating the round on-off knob at the end of the station 180°.

When a link is established, in the DiveTerm window choose: RUN DT-TEST.

Press #7 on your PC keypad to choose "7 (TX)". This will start the baseline station transmitting. You can adjust the frequency and speed, but these settings should be left on the defaults for these tests.

The frequency should be set to the frequency of interest minus 5 kHz. The default setting is 29 kHz, which monitors 34 to 41 kHz. You can adjust the frequency in 1 kHz increments by pressing the F1 function key on your computer keypad. The default speed is "slow." Pressing F2 will alternate between slow and fast speed.

When the baseline station is clicking (you may hear it, or feel it by putting your finger on the transducer), which indicates that it is transmitting a signal, you can disconnect the station and close DiveTerm.

Do not turn off the baseline station until after the range test has been completed. If it gets turned off, you'll have to repeat the entire setup process to enable the station to transmit, which requires use of a computer.

3. Conduct the range test.

The purpose of the range (TX) test is to measure the actual operational range of AquaMap at your intended study site by finding out the maximum signal strength at known distances from one transmitting baseline station.

Place a baseline station in your study area, preferably at the approximate location of where you plan to put BS1 or BS2.

Use the diver station to record the noise level at a known distance (e.g., 5 meters) from the baseline station. Remain in this position for approximately one minute and record the maximum signal received. Example of diver station display:

Gain (F1): 2

Frequency (F2): 29000

min/max: 006/084

Below the line under "min/max" is a graphic display of transmissions received. The "min/ max" will update every 10 seconds.

Moving along a straight line, record the noise level each time you have approximately doubled your distance from the baseline station. (e.g., at 10 m from the baseline station, then 25 m, 50 m, 100 m, and 200 m). The effective operational range generally ends at about 200 meters from the baseline station.

Although the signal propagation should be similar in all directions from the baseline station, if time and patience permit, noise levels may also be recorded for evaluation in other quadrants in the study area.

When this test is finished, turn off the baseline station but leave the diver station on.

4. Conduct the noise test.

The purpose of the noise (RX) test is to determine the general noise characteristics of your study site, with an emphasis on broadband noise, the most common type you will encounter. Broadband noise, which may be caused by biological sources (e.g., snapping shrimp), has frequency components across a wide range. However, you may encounter noise on a specific frequency, such as from a depth sounder or other piece of underwater acoustic equipment. This test will pick up noise from scuba regulators and impacts on the transducer, so try to minimize them. The baseline station should be turned off after the range test to eliminate the “pings” it emits.

During the RX test, the diver station listens on the selected frequency and measures the minimum and maximum signal detected in a five-second period. These signals are displayed numerically and graphically on the diver station screen.

You will need to have the diver station configured in the receive mode, as it was for the range test, so that it will detect ambient noise on the specified frequency range. Use Gain 2 and a frequency of 29 kHz.

Swim with the diver station to various locations in the study area, including the perimeter, near tall coral colonies and in both deep and shallow areas. After remaining in a location for at least a minute, record the maximum value you have seen on the diver station display while there. Also note if many signals are considerably below the maximum. (Since the maximum value is determined over a 15-second period, if many or most of the signals are lower than the maximum, your range may not be well represented by the maximum level indication.) Make sure you also record the gain and frequency that were used during the test. Perform the test in as many locations around your site as time and patience permit.

To end the test, press ENTER on the diver station, then F4 (OFF). You should now have a reasonable approximation of the noise characteristics in the study area.

5. Evaluate the test results.

Compare the signal received at known distances in the range test with the ambient noise levels as measured in the noise test. When the maximum signal received is equal to the average noise level, you have reached the maximum operational range. It's prudent to have the actual distance between the stations remain somewhat less than the average operational range measured (~75%).

In addition, in order for the system to reliably derive a position, signals must be above the maximum noise level you determined for the site. A good rule of thumb is to set the threshold level so that signals will be received at 1.5 times the average of the maximum values you recorded. For example: assume the maximum values for the 20 measurements taken during the noise test ranged from 0 and 15, with an average of 10. The AquaMap default setting for the threshold value, which is 12, could be used because it’s close to 1.5 times the average noise level for the area. If the average value was more than 10, you could increase the threshold value when you create or edit the configuration file for the stations, as explained on page 10.

You may use this information to modify the settings for “threshold” in the configuration file. Our experience in tropical waters has shown them to be fairly noisy environments and, as explained on page 8, a diver’s bubbles can cause interference with the SONAR signal. We generally use a threshold value of 15 on Gain 2, and have had success tracking with ranges to 200 meters, sometimes more.

B. *Initial Tracking*

After you know how to deploy the baseline stations (page 6) and load the right configuration file into the stations (page 9), you can begin tracking in your study site. The steps described in this section are repeated until you are satisfied with the quality of the SONAR signal you are receiving and you have marked the final locations of the baseline stations.

A baseline survey is a test or series of tests that provide critical data regarding the positions of the baseline stations. Before the system can map or track, it must have data from a baseline survey entered into the configuration file. There are two ways to accomplish this:

- In an initial baseline survey, the positions are automatically calculated and entered by the diver station underwater, as described in this section.
- In a definitive baseline survey, data obtained at the site are manually entered into the configuration file and then downloaded into the stations before returning to the site. This procedure is described in the section C, page 25.

1. Setting up for tracking.

You’ll need to do the following before you undertake tracking for any purpose, including either an the initial or definitive base line survey.

Anchor the boat. If the longest distance is between BS1 and BS2, you may want to anchor the boat midway between these locations as defined in your pre-dive planning. In that case, one diver would take the stations for BS1 and BS3, and a second diver the station for BS2.

Turn on the baseline and diver stations before entering the water. Leave the baseline stations on while they are in the water. Check the flashing light near the on-off switch.

— One blink per second means the baseline station is standing by, waiting for an interrogate, i.e., waiting to be surveyed.

— A fast double blink means an interrogate has been received.

— Continuous rapid blinking means the battery is low.

Caution: This is a strenuous technical dive with risks of entanglement and over-exertion. Divers are carrying both extra weight and flotation while swimming long distances. All divers must be familiar and comfortable with the dive plan and aware of emergency contingencies before starting.

Position the baseline stations in the locations you have selected. (See page 6.)

2. Measure the bearing of baseline #1.

You'll need to determine the compass orientation of baseline #1 so that when you've decided on permanent locations for the baseline stations you can enter the data into the configuration file. We do this by temporarily marking the locations with surface floats, then maneuver the boat so that we can get a compass bearing from the float on the line from BS1 to BS2. An alternative is to run a transect tape at depth between the sand screws or pins securing the stations, pull the tape taut, and measure the bearing along that line. If you later reposition the BS1 or BS2, you'll have to determine the new compass bearing and revise the configuration file accordingly.

> When considering the use of surface floats, keep in mind that wave action may be transmitted through a surface float and line to a baseline station, moving the station and decreasing position accuracy. Although helpful when determining the baseline orientation, floats are generally not a good idea during routine tracking and mapping. They make it easier to locate the stations, but increase the risk that the stations will be jostled during tracking.

3. Conduct an initial baseline survey.

In an initial baseline survey of your study site, you establish where the baseline stations are located by simply pressing a button on the diver station. This process is used to determine the depths of the baseline stations, and it is sufficient for accurate tracking and mapping during a single dive. However, because of the variability of measurements taken in moving water, position fixes obtained during an initial baseline survey way *may not* be repeatable at a later date, even if the baseline stations are deployed in the same place. (They could be used for future dives if the stations were not removed from the site, but the stations are too expensive to leave behind.)

Limitations. It's a matter of sample size. An initial baseline survey determines the location of the stations based on the reception of a single signal from each baseline station. The "error" in the data obtained in a single survey may be significant enough to affect the accuracy of mapping, tracking, and point relocation on subsequent dives. The data obtained in repeat baseline surveys are inevitably variable; two initial baseline surveys done during two different dives may produce slightly different positions for the baseline stations even if you deploy them in exactly the same locations. For example, if BS1 sways 35 cm to the east, BS2 sways 35 cm to the west, and BS3 sways 35 cm to the north, that can provide enough variation in the survey to create a position relocation error of more than one meter.

Because we use AquaMap to help relocate positions with sub-meter accuracy repeatedly over time, the position data must draw from a larger sample, increasing the reliability of the data by increasing the number of signals on which the data are based. To establish these distances precisely requires the reception of repeated signals, as is done in the definitive baseline survey, as described on page 25.

What the diver does. The diver should hover motionless in an area ~5m away from both baselines while the diver station is recording data. The diver should not change depth or location during this process, which takes about one minute.

Press the MODE button on the diver station to call up the main menu.

Use the 0/ key to move to select BASELINE.

Press ENTER to display the BASELINE DEFINE screen.

Press F4 (OK) to display the BASELINE CONFIG screen.

Press ENTER to clear any previous data from the ALLIGN field.

Press the numeric keys to enter the compass bearing for Baseline #1 in the ALLIGN field, then press ENTER. If a wrong number is entered, press F3 (DEL) to delete the mistaken entry and enter the correct number.

The cursor is now placed to enter data in the S-Depth field. But this is for the depth of the surface station, which we do not use, so just press ENTER. Although you do not see the data, the diver station is also noting the depths of the baseline stations.

The display will fill with zeros. Confirm this configuration by pressing F4 (OK). The diver station will beep and return to the DIVER STATUS screen.

What the diver station does. The diver station will display "NOW SURVEYING…," send interrogates to each baseline station in turn, and listen for a return signal.

- **If the diver station receives a reply,** it will send another interrogate, listen for a reply, then compare that value with the previous reply. If the two values are within a tolerance margin, the diver station will display what values it has accepted, send an interrogate to BS2 and repeat the process.
- **If the diver station does not receive a reply,** it will make eight more attempts to interrogate that baseline station. The number of the current attempt will be displayed on the screen. If a return signal is not received after nine attempts to interrogate a baseline station, the diver station will display the range data as N/A and the bearing data as 0.0 or N/A. The diver station will then proceed to interrogate any remaining baseline stations.

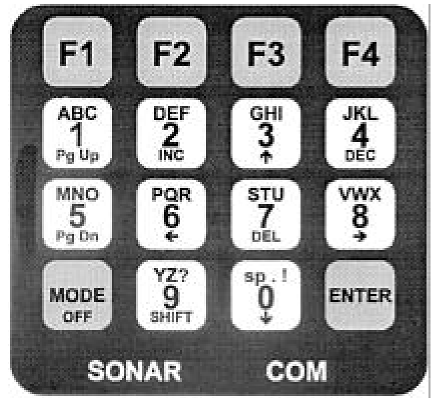
After all three baseline stations have been interrogated:

- If data values within the tolerance margin have been obtained for all three baseline stations, a **SURVEY OK** message will appear.
- If the diver station cannot communicate with one or more of the baseline stations, or if the data values obtained from any of the baseline stations do not fall within the tolerance margin, a **NO SURVEY DATA!** message will appear.

If you get the NO SURVEY DATA message, you'll have to reposition one or more of the baseline stations and try again. Although baseline data are entered into the configuration file during the initial baseline survey, they can be over-written or replaced in a subsequent survey on the same dive, unlike the data that are "hard-coded" into the configuration file during a definitive baseline survey.

4. Navigate around in the area.

After completing the initial baseline survey, you can practice using the diver station at your study site and evaluate the quality of your SONAR communications. You'll want to swim through the area several times at different depths while watching the diver station display to determine if communication is good within the entire site.



Using the diver station. To press a key on the diver station keypad, use the magnetic pointer. A feedback beep indicates that the key has been triggered. Most of the display screens have four labels across the bottom, positioned over the four function keys. These indicate the command that will be triggered by pressing that function key, e.g., pressing F1 when it appears under NXT on the screen will move you to the next screen. Most other keys on the keypad have multiple functions. The arrow keys are used to select entries from a list or to move around a data field. Refer to the AquaMap manual to learn about the information that is displayed on the diver station and how to get to the different screens. You will primarily be using the two navigation screens: general and precision.

5. Evaluate the SONAR signal quality.

The key indicators of the quality of SONAR communication within the site are:

- **Time since last fix.** This is displayed in the upper left of the general navigation screen, and lower right of the precision navigation screen, next to the label "l". During good signal communications, the diver station may be able to fix its location every 2 to 3 seconds. If you are moving and the time since last fix exceeds 30 seconds, your position may not be accurately reflected by the diver station. Try changing your depth and check to make sure that the transducer is not blocked by your dive buddy or your exhaled air bubbles.
- **Baseline signal indicator**. This is displayed on the lower left of the precision navigation screen, next to BASE.
  - An "l" means that a pulse was received during the last positioning attempt.
  - You should also see three "+" signs, one for each baseline station. If a "–" sign appears, it means that that signal is not getting through (e.g., if there's a minus sign in the second space, it means BS2 is not communicating).
  - An "i" means idle, i.e., no signal was received.
  - An "s" indicates that a signal has been received but its location could not be calculated, e.g., the baseline station is out of range.

Even in tropical waters, differences in temperature may affect signal propagation, so the diver station transducer should be in the same water temperature as the baseline station transducers. You can use your own sense of temperature to determine this; you don't need a thermometer. If you feel a significant thermoclyne (as often occurs near the water surface under intense sun), the signal may have difficulty passing through.

What if the SONAR quality is unsatisfactory? Although there may be times when one or more stations are not receiving signals, such a lapse should not continue for more than 90 seconds. If it does, check to make sure nothing is blocking the diver station transducer (e.g., a dive buddy, a school of fish, or the float on the diver station transducer). If you cannot locate any other source of the problem, you'll need to move one or more of the baseline stations and conduct another initial baseline survey, which can be done by over-writing the configuration file data in the diver station (see page 20).

6. **Record the site perimeter.**

As explained on page 12, the diver station can make two types of recordings, position and observation. You can use a position recording that you make as you trace your study site perimeter to test how well SONAR signals are received throughout the site and begin the process of identifying a sample population. Like the initial baseline survey, this step will need to be repeated after you've collected more data.

Go to the site boundary and choose an identifiable point from which to start.

At the DIVER STATUS screen, press F2 to go to the GENERAL NAVIGATION screen.

Press ENTER to display the PRECISION NAVIGATION screen.

Press F4 to change from standby to RECORD mode.

Circumnavigate the study site, swimming at a comfortable speed and making sure your dive partner does not block the SONAR signal path.

During this swim, monitor the "time since last fix" and the "baseline signal indicator" to check the SONAR signal reception in the study site.

When you are back at your starting point, press F4 to return to STANDBY mode.

If you are done tracking for the day, you can retrieve and turn off all stations.

Or, if you are working with a laptop in the field, you can leave the stations *in situ* and immediately download and convert the recorded data as described below.

7. **Download and convert the recorded data.**

Connect the diver station to your PC and go to DIVETERM.

Turn on the diver station.

When a link has been established, go to RUN SMTDIVE.

When the terminal window appears, go to the COMMAND drop-down menu and choose READ "TAPE" MEMORY (SMARTDIVE/MICROTRACK).

When the Select File window is displayed, select a name and location for the record file. We recommend using the default location.

Click on SAVE. A percent display will indicate the progress of the data download.

When the download is complete, turn off the diver station, disconnect it from the computer, and close DiveTerm.

Convert the data to display the position recording as a graph (see Appendix B).

After you've downloaded the file to your PC, you can clear the diver station memory so it will have space for your next recording (see page 13).

8. **Finalize the baseline station positions.**

Here are the considerations to keep in mind as you decide whether you're ready to finalize the locations for the baseline stations.

You'll want to reposition one or more of the baseline stations if:

- The diver station had to make many attempts to interrogate one or more baseline stations during the initial baseline configuration; or
- The baseline station indicator sporadically displayed " " (indicating that a baseline signal is not getting through) during the site swims or perimeter tracing, especially there was no consistent pattern of blockage, i.e., the " " bounced from station to station; or
- The position recording graph showed several large gaps between positions.

The baseline stations can be moved in all directions, depths, and orientation (transducer up or down), and each move can be considered for each station. If you reposition a baseline station, however, you will need to repeat:

the initial baseline survey;

the preliminary site swim watching the baseline station indicator on the precision navigation screen; and

the perimeter tracing and position recording, and display the new data as a graph in the AREA program.

You can leave the baseline stations where they are if:

- You had fairly rapid communications between the stations during the initial baseline survey. If the diver station received a reply from each baseline station after only a few attempts, this may indicate good sonar communication.
- While you were swimming in the study site, the baseline signal indicator display showed "+ + +" most of the time, you encountered only a few places where signals dropped out, and that was for less than 30 seconds. Even with good sonar communication, the number of times the signal drops out will vary depending on the size of the site. For example, in a large site which takes 10 to 15 minutes to circumnavigate while swimming, 10 to 15 dropouts would not be unusual.
- Evaluation of the position data graph displayed by the area program reveals no significant gaps between positions, or no more than a very few small gaps.

9. Mark and document the baseline station positions.

After you've decided where you want to locate the baseline stations, the locations should be marked at the site in a non-destructive manner and identified by GPS coordinates as accurately as possible.

- In sandy bottom, sand screws work well; in hard bottom environments, survey stakes or pins that have been modified to have a rust-resistant attachment "eye" at the top work well.
  - With its flotation collar, each baseline station is ~7 lbs. positively buoyant in salt water, but since minimal holding power is necessary, sand screws only need to be installed halfway into the sand, and the portion of the screw remaining above the sand will help during relocation.
  - To make it easier to relocate the sand screws or pins later on, connect them to submerged floats by 3 to 5 feet of line, and make detailed field notes and drawings.

- The lines used to attach the stations to the sand screws or survey stakes can be left at the bottom between dives or deployed only when using the stations.
  - Permanent lines allow for easy positioning of the stations at the correct depth during each use, but they will become bio-fouled, may sink to the bottom causing damage, and may be a navigation hazard if very shallow.
  - Temporary lines avoid the problems associated with permanent lines, but accurate notes must be taken regarding the depth of the stations. If you are scheduled to use AquaMap at the same site for several days, temporary lines can be left there until the work has been completed.

> Measure the depth of each station from the ON-OFF knob end of the station where the depth sensor is located, not from the transducer end.

Information on the locations of the baseline stations should be documented in the metadata file and stored with the site information (see page 36).

Integration with GIS. To provide another means of relocating the baseline stations over time and make it possible to integrate AquaMap with GIS data, you will want to get the GPS coordinates for the stations. This can be done with a portable or boat-mounted unit: get as close as possible to each baseline station, position yourself directly over it, steady the boat and/or GPS unit, and record the position. Software is being developed that will link the GPS coordinates to the sample positions and convert the X:Y coordinates to GPS.

C. *The Definitive Baseline Survey*

After you've settled on where you want to locate the baseline stations and you're satisfied with your ability to track and receive SONAR signals throughout the study area, you need to do a definitive baseline survey. This procedure uses the system's ability to measure "raw ranges," or the actual distance between the stations.

- **The diver swims to each baseline station**, turns on the position-recording feature, and remains at the station for 3 to 5 minutes while the system serves essentially as an acoustical measuring tape. The signals received by the diver station every 1 to 3 seconds measure the distance between it and each of the baseline stations. By increasing the number of measurements taken of the distance between baseline stations, we dramatically increase the sample size ("N = 80 to 120") from that used in the initial baseline survey ("N = 1").
- **After data have been recorded at all three baseline stations**, the recording is downloaded to a field laptop or office computer and used to determine:
  - the range of Baseline #1 (the distance between BS1 and BS2) and Baseline #2 (the distance between BS1 and BS3);
  - the angle between Baseline #1 and #2; and
  - the depth of each baseline station.
- **The depth of the baseline stations can be measured** using a depth gauge, but a more accurate measurement can be obtained from the data recorded by the diver station when you made the position recording. The first three lines in the converted

recording (lower display in the Convert window) are the baseline configuration data used when the recording was made, including the station depth.

These numbers, along with the bearing of Baseline #1 that you obtained on the initial baseline survey, are manually entered into a configuration file and loaded into each station. As long as the same configuration file is used at the same site with the baseline stations in the same place, position fixes obtained with data using the definitive baseline survey are repeatable and precise.

So you'll have enough space in the diver station memory, make sure you've erase the tape of any previous records before conducting another survey (see page 13).

1. Conduct the survey.

Position yourself with the diver station at BS1 and hold the transducers of the two stations approximately 0.3m apart without altering the location of the baseline station or blocking the signal path.

> Depending on current, surge, and wave action, positioning the diver station transducer can be difficult. Don't let your body block the signal path.

Press F2 and then ENTER to get to the PRECISION NAVIGATION screen.

Press F4 to change from standby to record mode. Keep the diver station at the baseline station for as long as possible while in record mode (at least 2 minutes, but more ideally 5 minutes). Using signals received every few seconds, the diver station will repeatedly record the horizontal distance measured between it and the three baseline stations. The vertical component of the distance (the result of any difference in the depth of the stations) is automatically removed.

> Be careful not to move the baseline station during the survey and to minimize the motion of the diver station transducer, which serves as the reference point for multiple range calculations**.** Any movement will degrade the accuracy of the survey.

When you're done at BS1, press F4 to turn off the recording feature and remain in standby mode while swimming to BS2. This will make it easier to extract the baseline survey ranges that are needed.

Repeat the transducer positioning and recording process at BS2 and BS3. This will give you the distance between the three stations.

2. Analyze the recorded data.

a. ***Download and convert the data.*** You need to download the recording from the diver station to your PC (page 12) and convert the data as summarized below (see Appendix B for more details). This converted file will be imported into an Excel spreadsheet for data analysis.

When the download is complete, go to START and choose: PROGRAMS DIVETRACKER CONVERT.

Go to the FILE drop-down menu and choose LOAD A NEW RECORD.

You will be prompted to choose the file that you want to convert (the one you just downloaded and saved), and the configuration file that was being used when the recorded file was created.

When prompted to confirm that the download was created from a mobile station, click on YES.

At the Settings window, in order to view only station depths and raw baseline lengths, do not check either SHOW RAW AUTO-POSITION DATA or SHOW X/Y AUTO-POSITION DATA.

Click on OK to convert the data.

b. ***Determine the baseline station depths.*** After data is converted, the lower part of the screen will display a single line of data for each baseline station. The depth of the baseline stations can be found in the far right column, measured in meters.

Copy the baseline station depths to the metadata file (see page 36). You will need this information when you edit the configuration file in order to add the baseline station range data. Although the depths are entered into the configuration file in meters, most depth gauges read in feet, so it is useful to convert the meters to feet (multiply by 3.281) and have both numbers available.

In the Convert utility, B0 = Baseline Station 1, B1 = Baseline Station 2, and B2 = Baseline Station 3. B3 does not contain data because we only use three baseline stations.

c. ***Display the baseline range data on a spreadsheet.*** To get the baseline ranges, you will reload the same file of recorded data, choose the configuration file that you used when the recorded file was created, and confirm that the download was created from a mobile station.

But this time in the Settings window, place a check next to SHOW RAW AUTO-POSITION DATA.

When the data has been converted, which will takes less than one minute, go to FILE SAVE POSITION DATA FOR IMPORT.

In the OBSERVATION fields, place a check in all four boxes for ROUND TRIP LENGTHS: 1, 2, 3, and 3 (3 appears twice). Leave the DELIMITER as a semicolon. Click on OK.

You will be prompted to save this as a *.dbi file; do so with a unique name to the default location (C:/Program Files/DiveTracker/Records), then close Convert.

Open a blank worksheet in MS Excel.

Go to FILE OPEN. Select the *.dbi file you just saved (usually in (C:/Program Files/ DiveTracker/Records).

If you don't see any *.dbi files listed, make sure you've selected all files on the "Files of type" menu in the Open file dialog box.

The Text Import Wizard will appear. Within the field for CHOOSE ORIGINAL DATA TYPE, select DELIMITED, which is usually the default. Click on NEXT.

In the DELIMITER field, remove the checkmark next to TAB and place one next to SEMICOLON.

Click on FINISH. The converted data will be displayed on the spreadsheet.

A	B	C	D
B1 Data Series			
0.7366	96.5802	44.45000	-1
0.7366	95.30080	44.98340	-1
0.8636	96.95180	47.0662	-1
1.4478	-1	45.1866	-1
0.6858	95.70720	45.38980	-1
1.7526	95.42780	46.71060	-1
0.635	95.0214	44.55160	-1
1.4478	95.04680	-1	-1
0.9398	95.22460	45.05960	-1
0.8382	95.70720	45.77080	-1
1.5494	-1	-1	-1
0.6858	95.19920	45.11040	-1
0.5842	95.88500	45.5676	-1
0.508	95.8088	44.80560	-1
0.6604	94.86900	44.70400	-1
0.6604	94.9198	44.577	-1
3.1242	-1	44.83100	-1
1.5494	96.98660	44.3992	-1
0.2286	95.12300	44.37380	-1
0.127	95.42780	44.2976	-1
	[illegible]	[illegible]	[illegible]

A	B	C	D
B2 Data Series			
98.04400	0.254	116.459	-1
-1	1.3462	-1	-1
-1	0.5334	-1	-1
96.95180	1.3716	117.65280	-1
96.36760	0.254	116.35740	-1
95.17380	0.635	116.07800	-1
96.03740	1.3716	-1	-1
-1	0.762	-1	-1
82.06740	0.4572	117.85600	-1
-1	0.4826	-1	-1
95.73260	0.2794	-1	-1
97.33280	0.5842	118.79580	-1
97.48520	0.635	-1	-1
-1	1.1938	-1	-1
-1	0.1524	-1	-1
96.54540	0.1016	-1	-1
96.26600	0.0762	117.22100	-1
96.4692	-1	-1	-1
95.88500	0.1524	-1	-1
95.5802	0.1778	116.38280	-1
95.42780	0.2032	116.05260	-1
96.08820	-1	116.05260	-1

B3 Data Series		
46.30420	116.5606	0.3556
43.89120	116.63680	0.0508
44.47540	115.57	0.3302
47.54880	115.57	0.1778
45.03420	115.41760	0.127
44.78020	115.36680	0.381
44.78020	116.43360	0.2794
45.61840	115.82400	0.2032
45.49140	116.05260	0.3302
47.32020	115.62080	0.1524
44.42460	115.97640	0.1778
43.91660	116.05260	0.1016
43.91660	115.57	0.0508
43.99280	115.62080	0.2032
43.84040	117.60200	0.4572
44.17060	116.25580	0.127
43.94200	115.39220	0.4572
43.81500	115.84940	0.1016
-1	-1	0.2794
44.47540	116.33200	0.0254
44.04360	119.17680	0.3302
44.9072	115.54460	0.1016
43.76420	115.69700	[illegible]

The spreadsheet will display the data in sets of four columns. The values in columns A, B, and C indicate the distance in meters from the diver station to each of the three baseline stations (BS1, BS2, and BS3), as recorded by the diver station every few seconds while you were receiving signals at the site. Column D is all null data because it is for a channel that looks for data from a surface station or a fourth baseline station, neither of which we use.

The values in Column A, which indicate the distance between the diver station and BS1, should start out close to zero and generally be less than 1 meter because you were positioning the diver station transducer as close as possible to the BS1 transducer. (Ignore any negative values, i.e., -1, -2, -3, as these indicate errant signals.) When you reach a certain roll as you scroll down, the values in Column A will abruptly increase and the values in Column B drop close to zero. This row is the first data you recorded after moving to BS2. Consequently, the distance from the diver station to BS2 (shown in Column B) is very small, while the distance indicated to BS1 (Column A) is now similar to that in Column B in the preceding rows.

d. ***Separate the range data into three sets.*** To determine the distance between the baseline stations, you will need to separate the spreadsheet data into three sets according to which of the three baseline stations the signals were recorded at.

To separate the data recorded at the BS1 position from that recorded at the BS2 position, scroll down until you reach the row where the values in Columns A and B abruptly change. HIGHLIGHT the four cells in that row and the rest of those four columns down to the end of the data.

CUT that data and PASTE it at the top of Column F.

Scroll down until the values in Column F abruptly increase while those in Column H drop close to zero. This indicates the first row of data that you recorded after moving to BS3. HIGHLIGHT the four cells in that row and the rest of those four columns down to the end of the data.

CUT that data and PASTE it at the top of Column K.

You have now divided the data into three sets according to the baseline station at which it was recorded. You can label these data sets by inserting a row above the data and entering the label, “B1 Data Series” in cell A1, “B2 Data Series” in cell F1, and “B3 Data Series” in cell K1.

e. ***Determine the average and median values.*** Use the average and median of the data to make a best estimate as to the distance between the three baseline stations.

> When calculating average and median values, be sure to exclude the negative values in the Excel formula cell range.

To calculate the average and median range for Baseline #1 (the distance from BS1 to BS2), take the average and median of the values of Columns B and F.

To calculate the average and median range for Baseline #2 (the distance from BS1 to BS3), take the average and median of the values of Columns C and K.

To calculate the average and median range for Baseline #3 (the distance from BS2 to BS3), take the average and median of the values of Columns H and L. Although Baseline #3 is not used in the field, the value is used in the Law of Cosines to find the angle between Baseline #1 and Baseline #2, as explained below. It is necessary to include this angle in the configuration file to complete the definitive baseline survey.

f. ***Evaluate the results.***

Look at the differences between the average and the median for each range. Keep in mind that although negative numbers should be excluded, the average values do include any noise or poor signals. The median value represents the “middle” of the list of numbers, and may be the better option. Choose one value to use for the length of Baseline #1 and one for Baseline #2.

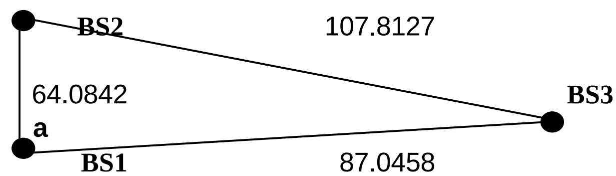
In addition to using these values to edit the configuration file as described in the next step, these data and the depths of the baseline stations should be stored permanently somewhere safe so that you do not have to repeat this process if the electronic configuration file becomes corrupted, deleted or lost.

> The main purpose of this data analysis is so you can be consistent in positioning the baseline stations and in the range and angle data entered in the configuration file. If you always position the baseline stations in the same place and always use the appropriate data in the configuration file, AquaMap will attempt to locate the points in the same place. The accuracy of the baseline ranges becomes significant only if you want to geo-reference sample points using GPS.

g. ***Determine the angle between baselines #1 and #2.*** The easiest way to calculate the angle is to use the diagram on the spreadsheet, where the formula has been incorporated.

Go to the bottom part of the spreadsheet, below the sections for calculating the average and median baseline ranges, where it reads: “Now Calculate the Angle between baseline-1 and baseline-2”. The exact location of this depends on how many rows of data you imported to do the range calculations.

Sample Spreadsheet Baseline Diagram



c^2=a^2+b^2-2 a b cos(a)

a= 89.69095

The values shown in the triangle diagram for the length of each baseline and angle "a" between baseline #1 and #2 are the numbers that were in the spreadsheet when it was last saved. The proportions of the diagram may not fit your site, but you need to assign the correct values to baselines #1 and #2 as they exist at your site. (Baseline #1 is the vertical line, baseline #2 is the nearly horizontal line to the right of baseline #1, and baseline #3 is the longest line.)

Enter the values you have determined for the baseline lengths in step 7 in the same cells as the current values. If you input the data in another cell, it will not be read by the formula and the calculation will be in error.

As you change the baseline values, the value calculated for angle “a” will automatically change where it appears just below and to the left of the triangle display. This is the value you will enter into the configuration file.

Save this worksheet with a name unique to the site.

If you'd like to work through the law of cosines yourself, you can use the following:

The Law of Cosines

$c^2=a^2+b^2-2\ a\ b\ (\cos[a])$

“a” = the angle between Baseline #1 and Baseline #2.

OR

$$\text{“a” = inverse cosine of } \frac{(\text{Baseline \#1})^2 + (\text{Baseline \#2})^2 - (\text{Baseline \#3})^2}{2 \times (\text{Baseline \#1} \times \text{Baseline \#2})}$$

all divided by (180x Pi)

3. Edit and reload the configuration file.

The baseline survey data that you have calculated in the preceding steps must be manually added to the configuration file you are using at the site. This file editing procedure is summarized below; see page 10 for more details.

On your PC, go to start and choose: PROGRAMS DIVETRACKER DIVETERM.

Go to FILE OPTIONS and select USE METRIC UNITS.

On your PC, open DiveTracker and go to DIVETERM FILE EDIT A CONFIGURATION FILE ADVANCED EDIT.

In the Select Configuration File window, open the same configuration file that you used to do the definitive baseline survey.

In CONFIG-3, you will need to enter the data from the definitive baseline survey.

- Enter the baseline station depths in meters as determined in step 2-b.
- Enter the range (length) for baseline #1 as determined in step 2-f above.
- Enter the bearing of baseline #1 as determined on page 20.
- Enter the range (length) for baseline #2 as determined in step 2-f above.
- Enter the angle between baselines #1 and #2 as determined in step 2-g. This entry is confusing because the cell label is similar to that for the bearing of baseline #1, but the correct entry is for the angle between baselines #1 and #2.

Click on NEXT twice to get to CONFIG-5. When you click on OK, you will be prompted to enter a file name and location. Then click on SAVE.

Note the file name in the metadata file for this site.

> Always use this configuration file when surveying this particular site unless you relocate the baseline stations. If you must move the baseline stations, you'll need to repeat the definitive baseline survey and re-edit the configuration file.

After the configuration file has been edited, you need to reload it into the diver and baseline stations as explained on page 11.

When the revised configuration file had been downloaded into all of the stations, they are ready to be used at the study site. At this point, you will want to conduct a definitive perimeter swim and recording.

> If the diver station is loaded with a configuration file in which the baseline configuration data has been manually entered, a baseline survey cannot be conducted because the hard-coded data will over-ride the system's ability to store new configuration data.

4. Make the definitive perimeter recording.

This is the same as the initial perimeter recording, except that the stations now have the definitive baseline survey loaded, and this recording will be used to define your sample area and create random sample points.

As explained starting on page 23, after you've erased the tape to clear the diver station memory, you can repeat the steps to:

Record the site perimeter;

Download and convert the recorded data; and

Save the data as a *.dbi file.

This file is then loaded into the AREA program (see Appendix C) so that you can:

- define the sample population,

- randomize that population,
- select the number of sample points you need, and
- download the points to the diver station.

D. *Navigating to Waypoints*

As described the preceding section, by this point you should have:

- downloaded the definitive perimeter recording;
- used the AREA program to generate random sample points;
- modified the site configuration file by adding the sample point coordinates; and
- loaded the configuration file into the diver and baseline stations.

For information on how to use the AREA program and load the Waypoints into the diver station, see Appendix C. The X:Y coordinates are displayed on the precision navigation screen, but sometimes you want to refer to them when you're at a different screen. To keep them in sight, we put a piece of duct tape on the diver station above the display window and write 10 to 15 coordinates on the tape with a permanent marker. These should all be double-checked for accuracy before going into the field.

1. Locating Waypoints.

To navigate to a particular point, you monitor the general and precision navigation screens. To move between the two screens, press ENTER.

To go to the GENERAL NAVIGATION screen from the DIVER STATUS screen, press F2. In this screen, you call up the destinations for navigation. The system will scroll through Home, B1, B2, B3, then the Waypoints. ((B1, B2, and B3 are the three baseline stations and if you are not using a surface station, Home and B1 are the same location.)

To get to the next Waypoint, press F2 again, or you can press #2 (INC) on the diver station keypad to go "up" the queue (i.e., Home, B1, B2, B3, then Waypoints 1, 2, 3, 4, etc.) Pressing #4 (DEC) will take you "down" the queue, reversing the order of Waypoints.

To navigate to a selected Waypoint, use a hand-held or hose-mounted compass positioned at least six inches away from the diver station. Use the "bearing to destination" on the upper right of the general navigation screen as a guide. While moving on that bearing, the "range to destination" (upper left of screen) should decrease. The "cross track error" number below the "range to destination" tells you how far you are from the line that connects two consecutive Waypoints. This is useful if you are proceeding up the queue from one consecutive Waypoint to another, but not if you are navigating to non-consecutive Waypoints or selecting a Waypoint "down the queue" of saved points.

> To prevent needle deflection, hold the compass as far away as possible from the diver station, which is metal and contains batteries.

Use the X:Y coordinates stored on right side of the general navigation screen or written on the diver station to find out where you're supposed to be heading. As the range decreases to <10m, slow your swimming speed. The bearing will fluctuate around the saved Waypoint, trying to home you in on the exact spot.

When the range reads <3m, press ENTER to switch to the PRECISION NAVIGATION screen. This will display your X:Y position and the RMS error ("E") so that you can fine-tune your position and determine the quality of the position fix. The larger the error number, the lower the data confidence. (See box on page 33.)

Also monitor the "time since last fix" shown after the label "L," which is located in the upper left of general navigation screen and the lower right of the precision navigation screen. This will tell you the time interval since the last successful communications between the transducers.

Use your mental image of the reef and the axis system to guide you in the proper direction, modifying the X:Y coordinates of your actual location so that they match as close as reasonably possible those of the location you are trying to track. This may take several minutes of adjustment and slight movements. Use good buoyancy control to avoid contact with the reef and having the transducer signals blocked by the reef or your dive partner.

2. Understanding RMS error.

The diver station saves its recent position fixes in a queue file. The root mean square (RMS) error indicates the reliability of your current X:Y position as shown on the diver station by calculating the average distance between the positions in the queue. While you are stationary, the positions in the queue should be very similar and the RMS error therefore relatively low. As you start moving and the positions in the queue become farther apart, the RMS error becomes higher.

The number of fixes used to determine the RMS error is displayed on the lower right of the precision navigation screen, next to label C (between D = depth and L = time since last fix). The default is 10. This means that when you first reach a point you wish to record, the position queue will contains a string of 10 position fixes tracking your previous path, resulting in a high RMS error. You can wait a few moments for the RMS error to decrease as additional fixes are taken where you have stopped, or you can immediately lower the RMS error by pressing F3 (CLR), which will to reduce the queue to 2. Pressing F3 again will return the queue to 10 position fixes.

When you create or edit the configuration file, you can change the default 10-position queue. We recommend using 5 positions, which gives you relatively high accuracy without having to wait for 10 clear consistent positions. Pressing F3 will still reduce the queue to 2, a number that cannot be modified.

For example, the display next to "C" may read 02/02. The top number is the number of points being used to calculate the RMS error and the bottom number is the number of points in the queue position string (as defined in the configuration file). C: 03/05 would mean that the last 3 positions are being used but 5 are being sought to calculate the RMS error. As another position is fixed, the display will change to C:04/05. C:05/05 would mean the last five positions are being used to calculate the RMS error.

3. How do you know when you're there?

When tracking to a Waypoint, you'll find that you're swimming to a point that is defined only by X:Y coordinates and looking at a "general navigation screen" with a fluctuating "range to destination" and a "precision navigation screen" with a fluctuating RMS error. How do you decide when you've reached the designated Waypoint? A reasonable answer is: you can consider yourself at the Waypoint when:

- you're within 0.5m of the X:Y coordinates; and
- your RMS error is less than 0.5m.

At that point you can tie off the transect tape if you are laying one, or make an observation recording, if you are collecting data on random sample points as described in the next section.

4. Making observation recordings.

Observation recordings differ from position recording in that:

- Instead of recording a series of sequential positions, observation recordings are made at specific points. They can be used to record the transect origin and terminus, for example, and the location of specific features of interest.
- Instead of recording only the location of a point, observation recordings can be used to collect other information by specifying this in the configuration file.
- The RMS error is displayed and recorded during observation recordings, so you know the accuracy and precision of the location where the observation was made.
- To modify the configuration file to record observations, apply a check mark to that option in the "Edit Diver Observation Records" in the Config-5 screen of Advanced Edit/Create. As shown in the configuration settings list in Appendix A, we recommend these data be included in all observation recordings: Automatic Depth, X, Y, RMS Error, and Temperature.

When the configuration file is loaded in the diver and baseline stations, this information will be recorded each time you press F2 from within the precision navigation screen. Once the observation recordings have been made and the sample taken, you are ready to navigate to the next Waypoint. This continues till the sampling is complete, or your bottom-time or air pressure indicates that you need to surface.

The procedure for downloading and converting observation recordings is the same as for position recordings, as explained on page 12 and in Appendix C. Data are typically imported to an MS Excel spreadsheet or saved for display as text. To save observation data for import when the conversion is complete:

Go to FILE SAVE POSITION DATA FOR IMPORT. (There is no option to save observation data for import, so select this menu item.)

In the Save for Import dialog box, put a check in each of the seven boxes next to: DEPTH, X, Y, RMS ERROR, TEMP, NORTHING and EASTING. Make a mental or written note that you are saving these categories from the observation recording for use when the data are displayed in the Excel spreadsheet. In the Delimiter box, put a semicolon (;). Then click on OK.

In the Save Import box, select a name and location for this new *.dbi file. (We use the default, C:/Program Files/DiveTracker/Record/.dbi.) Then click on SAVE.

Recovering the baseline stations: Remember to save both air and bottom time for retrieving the baseline stations at the end of the last dive. They may be some distance from where you are tracking and take considerable bottom-time, air, and energy to retrieve, unless they can be retrieved by snorkeling.

E. *Relocating Waypoints*

So, a year has gone by, and it's time to go out and sample the random sites you selected last year. What do you we need to do to resample the points?

1. Retrieve information from the configuration files and other metadata sources.

Review any notes or charts from the previous sampling.

Verify the presence of all necessary files on the computer and/or field laptop.

If using the videotaping protocol, consider capturing swim-back photos that show the transect placement. The videotaping protocol explains how you can put these photos on a single laminated page for each transect.

2. Prepare the equipment.

Locate the depths of the baseline stations from the configuration file, and find lines appropriate to secure their positions.

Charge system batteries (yours and AquaMap's).

Write the depths of the baseline stations on a slate to accompany deployment of the baseline stations.

Load the configuration file into the diver and baseline stations.

Write the X:Y coordinates for the Waypoints on duct tape that has been put on the diver station.

Carefully review the dive plan, contingencies and steps for finding baseline stations positions at the site. With the passage of time, any submerged lines will be bio-fouled and pins that were once easy to locate will be camouflaged.

3. Set up at the study site.

Position the baseline stations.

Use the General and Precision Navigations screens to re-locate the sample (e.g., transects).

If using the video method, use the laminated photos to aid in the exact placement of the transect.

Use the observation recording feature to save the coordinates for the sample position, i.e., the origin and terminus of the transect.

4. Save the recorded data.

After a day of re-sampling, download and save the recorded data to a computer.

Erase the recording tape.

Repeat steps 3 and 4 until all samples have been revisited.

V. Data Management and Summary Chart

A. *File and Data Management*

Following these AquaMap protocols will result in the creation of many files in a variety of formats (e.g., *.rec, *.dbi, *.wpt, *.par), some of them vital to the data's ongoing value. Therefore it's essential that you track and document the file names and storage locations so that others can use the files in the future. Among other tasks, this means that you need to:

- Compile all data files into a central computer location (directory or folder).
- If you are using more than one computer, be sure to consolidate files. Using a laptop computer in the field is helpful, but make certain that you also save or transfer the files to a desktop computer.
- Keep a metadata file log (a "readme" text file) in a central location that lists the names and storage locations of all files created. Make written notes of the names of all files used such as configuration, Waypoint, recordings, and converted files. Trying to remember which file contains which information can be difficult after you've moved on to another site.

B. *Creating a Data Summary Chart*

You may want to display data in a MS Excel chart to display various data positions and text information, including: name of the site; perimeter trace (position recording data); baseline station locations and coordinates, sample point positions and coordinates, baseline bearings and station depths, and locations of any permanent sample positions or transects.

The summary chart can also be used to:

- Display the difference between the target sample coordinate points and the actual sample positions as documented in the observation recording. This can be summarized in a statement such as: "average difference X direction = *0.4*m, average difference Y direction = *0.38*m."
- Compare sample position precision on subsequent years. For example, if random samples were established in 2001and re-sampled in 2002, one set of points can be used to display the 2001 sample positions and another set to display the actual sample positions as documented in the observation recordings for 2002. From these coordinate values, you can also evaluate the average absolute difference between the two points.

To create a summary chart, you will need to run the recorded data through the Convert program (see Appendix B), import the data into an Excel workbook, and create text boxes within the chart.

1. Import the converted data recording files into MS Excel.

Open MS Excel and go to FILE OPEN. At the bottom of the dialog box and select ALL FILES as the file type.

Open the *.dbi file of the recorded data you want to display.

The dialog box for the Text Import Wizard should open. Click on OK to proceed to the second wizard box.

Select semicolon (;) or other delimiter as necessary to separate the data into columns. You can see the results of your selections in the data preview.

Click on FINISH. (If you select NEXT instead of finish, leave the default for column data format as GENERAL.)

The data will appear in spreadsheet columns, but it is imported without headers so you will need to label the columns. (You have to remember which components were included when the position data was converted to create the *.dbi file.)

- Insert a row above the data set. (Click on the number 1 that identifies the first row of the spreadsheet to highlight it, then go to the Insert drop-down menu and select ROW.)
- Label the columns of data you have just imported as described below.

For position data:

Position data are imported to two columns headed NORTHING and EASTING.

Label the next two columns X and Y.

The Northing and Easting values must be converted into X:Y coordinates. The formulae are: **X = Easting** and **Y = -1 x (Northing)**. This means that:

- For the X coordinates, you can copy the data from the Easting column into the X column.
- For the Y coordinates, multiply the cells containing the Northing values by –1, i.e., in the first cell under the header Y, enter: "**= –1***" followed by the label of the cell containing the first Northing value.

For observation data:

If you followed the suggested protocol for making observation recordings, these data will be imported to seven columns on a separate spreadsheet. They should be headed DEPTH, X, Y, RMS ERROR, TEMP, NORTHING and EASTING.

Select the headers and all data from the observation recording spreadsheet.

Go to EDIT and choose COPY.

Switch to the window containing the spreadsheet with the imported position data.

Paste the observation data in the next available columns to the right of the position data.)

The spreadsheet from which the observation data was copied can be closed without saving it, as these data have been added to the initial position data spreadsheet.

2. Save the recording data spreadsheet.

Go to FILE SAVE AS. At the top of the dialog box, browse to the appropriate SAVE IN location.

At the bottom of the dialog box, select MICROSOFT EXCEL WOOKBOOK as the file type.

Type in the appropriate file name. The ".xls" extension will automatically be added and should not be entered as part of the name.

Click on SAVE.

3. **Generate the summary chart.**

Select the two columns containing only the position X-Y data, not the header.

Press the Chart Wizard button to open the Chart Wizard.

For Step 1 of 4, Chart Type, select X Y (SCATTER) as chart type. For the chart sub-type, select the top one, which has points without lines and is described as "Compares values of pairs." Click on NEXT.

Step 2, Chart Source Data: no changes are necessary. Click on NEXT.

Step 3, Chart Options: you can enter a chart title at this point if you wish. Do not label the X or Y axis. Click on NEXT.

Step 4, Chart Location: under PLACE CHART, select AS A NEW SHEET and either rename the chart at this time or use the default name. Click on FINISH. The chart containing the position data will be displayed in a separate spreadsheet within the workbook labeled CHART.

4. **Add the transect origin and terminus point.**

Position the mouse on the chart background (not on an axis gridline or sample point), press the right mouse button and select SOURCE DATA.

In the Source Data window, select the SERIES tab and click on ADD.

For Name, enter "transect positions."

For the X and Y Values, you need to reference the location in the spreadsheet that contains the data you want to add. Start by clicking on the spreadsheet icon to the right of the X Values box. This will open the Excel spreadsheet and the Source Data – X Values window.

Click on the appropriate tab in the spreadsheet, and then select the data containing the X coordinates for the transect positions. This will link the data to the Source Data – X Values window. Close that window by pressing the X at the upper right corner. That will return you to the Source Data window.

Repeat the same procedure for the Y values, except select the Y coordinates for the transect positions.

This chart will help summarize the work done at a study site. It can be modified to meet the needs of the target audience. It may be helpful to laminate this plot for use underwater during subsequent year samplings.

APPENDIX A

Recommended Configuration File Settings

Screen	Simple	Advanced
CONFIG 1	We use the defaults: – Environment Type: Open Ocean. – Number of Surface Transducers: 0.	Use defaults for all settings. They are: • Depth Compensation (cm): 76.200. • Max. Operating Depth (meters): 76.200. • Max. Baseline Range (meters): 350.000. • Max. Mobile Slant Range (meters): 350.000. • Origin Northing (meters): 0.000. • Easting (meters): 0.000.
CONFIG 2	– Number of Baseline Stations: The default is 2; we use 3. – Number of Mobile Stations: We use the default, 1 (for the diver station).	• Network type: Mobile Station, 3 baseline, Mobile interrogated. • Communication Speed: 8.9 nibbles/sec (35.7 baud). • Address Mode: double ping, address code interrogated.
CONFIG 3	Water Temperature: The default is 10ºC; we use 28°-30°C in the Caribbean. This screen also provides access to the “Edit Waypoints” screen (see page 41)	The baseline station depths and the baseline ranges and bearings are all set initially at 0. You’ll enter the actual settings after you conduct the baseline survey. Do not modify the following default settings for turn around time and channel frequency: • Turn Around Time (uSec): 100000. • Channel 1 Freq (Hz): 33898. • Channel 2 Freq (Hz): 36364. • Channel 3 Freq (Hz): 38462. • Channel 4 Freq (Hz): 40816. • Water Salinity (ppt): 35. Adjust as necessary for fresh or salt water. • Default Water Temp: Because it is needed in order to accurately calculate the speed of sound in the water and therefore distance, you should estimate or measure the water temperature for the site in which you are working as precisely as possible. The diver station measures the water temperature where it is located, but the value entered here will be used if the temperature-sensing device fails. The default is 10ºC; we use 28°-30°C in the Caribbean. • Pos. Avg. Sample Size: This is the number of values stored to calculate the RMS (root mean square) error displayed in the precision navigation screen. The default is 10 positions. We prefer to use 5 positions, which provides a reasonable trade-off between precision and the time it takes to get a reading. • Max RMS error (m): 0.914. Do not modify this default setting. • Distance Between Auto Search Lines (cm): 0.000. Use this default initially. It can be modified if you want to do a programmed search pattern.

Recommended Configuration File Settings

(continued)

Screen	Advanced Create or Edit Configuration File Settings
CONFIG 4	We recommend that you leave all of the following settings at the default values. • Gain: 2. • Detection Threshold Level: 12. Change if necessary as a result of your noise test or subsequent experience at the site. • Transmit Power: 127. • Pulse Length (uSec): 4000. • AGC (Automatic Gain Control): If this box is checked, the AGC is enabled, which means the AGC will do a gain adjust every 3 to 5 minutes. If the diver station transducer is affected by bubbles when the gain adjustment is made, the AGC may be set too high, eliminating signals. You may wish to disable the AGC (remove the checkmark) to avoid this. • AGC Activation Interval (Sec): 120. • AGC Min 'No Positions' Interval (Sec): 15. • AGC/Noise Test Duration (Sec): 5. • AGC Max Number of Noise Events: 1. • Baseline no-activity shutdown period (seconds): 120. • Baseline Station sleep periods (seconds): 120. • Baseline Station post-sleep listening periods (seconds): 15. • Mobile Station no-activity shutdown periods (seconds): 0. • Mobile Station sleep periods (seconds): 0. • Mobile Station post-sleep listening periods (seconds): 0.
CONFIG 5	• Telemetry Type: 2-channel telemetry (default). • Data availability: Surface Station only (default). Do not select any of these three boxes: Serial Transfer Raw Position Data, Serial Transfer X-Y Depth Position Data, or Serial Transfer Message Data. • Number of Mobile Stations: 1. The remaining six boxes represent buttons that allow you to modify the contents they describe. Eventually you may want to modify the contents of the EDIT WAYPOINTS or EDIT DIVER OBSERVATION RECORDS screens, as shown next.

Recommended Configuration File Settings

(continued)

Optional screens for additional configuration file functions:

EDIT WAYPOINTS (see page 48)	This screen is used to load Waypoint files or modify a Waypoint. • The bottom of the display should read that all the coordinates are in meters. • The "Do Not Use Baseline Relative Coordinates" box should not be checked. • When closing this window, if you want to save your changes, select OK, then follow the directions to save the file under a different name. If you do *not* want to save the changes, select CANCEL. • To create the Waypoints for a search pattern, select CREATE SEARCH PATTERN.
CREATE SEARCH PATTERN	This screen enables you to define the parameters of the search pattern. • Define Start Position X and Y. • Define the compass bearing *relative to the bearing of the baseline* of the first leg of the search pattern. For example, if your direction of travel will be parallel to the bearing of the baseline, this value should be "0" degrees. • Check or un-check the box for FIRST TURN RIGHT as appropriate. • Fill in the appropriate values for LEG LENGTH, SEPARATION & SEARCH AREA WIDTH.
EDIT DIVER OBSERVATION RECORDS (see page 34)	This screen designates which data are recorded when the observation button is pressed from within the precision navigation screen. If you want to relocate a point later on, this is the most accurate way to save the position, and it also records the RMS error value. We suggest checking the boxes for AUTOMATIC DEPTH, X, Y, RMS ERROR, and TEMP. These data will be displayed in columns when the tape is downloaded.

APPENDIX B

Using the Convert Program

Convert™ is a utility program developed by Desert Star Systems that can be used to convert position and observation recordings to a useable format. To use it, you need to have both the configuration file that was being used when the data was recorded and the downloaded recording (a *.rec file) on your computer hard drive.

1. **Load the file.**

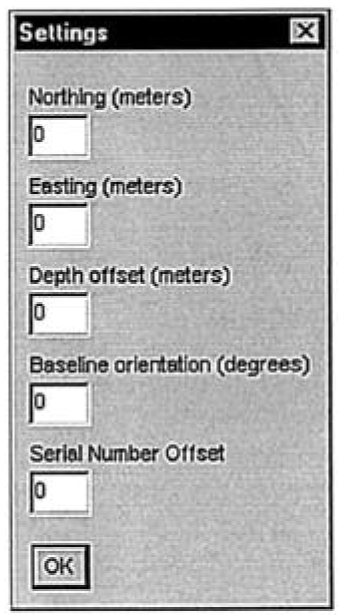
   Go to START and choose: PROGRAMS DIVETRACKER CONVERT.

   Go to the FILE drop-down menu and choose LOAD A NEW RECORD.

   You will be prompted to select the *.rec file that you wish to plot.

   You will be prompted to select the configuration file (*.par) that was being used when the record file was being created.

   When prompted to confirm that the download was created from a mobile diver station (rather than a surface station), click on YES.



2. **Select the settings.**

   When the Settings dialog box appears, make sure that a “0” is entered in all five fields: Northing (meters), Easting (meters), Depths offset (meters), Baseline orientation (degrees), and Serial Number Offset. The default settings are all “0” except for Baseline orientation, which will show whatever value you entered for the compass bearing in the configuration file used during the recording.

   At the bottom of the dialog box, you can check off one or neither of the two options (SHOW RAW AUTO-POSITION DATA and SHOW X/Y AUTO-POSITION DATA) depending on what are going to do with the data and how you want it displayed. Some common examples are:

Use of data	Recording	Choose
• Display perimeter trace in the Area program	Position	SHOW X/Y AUTO-POSITION DATA
• Evaluate SONAR effectiveness by looking at tracking data to see from which station missed signals were recorded	Position	SHOW RAW AUTO-POSITION DATA
• Plot transect origins and terminuses on MS Excel graph	Observation	SHOW X/Y AUTO-POSITION DATA
• Note transect origins and terminuses in metadata file	Observation	SHOW X/Y AUTO-POSITION DATA
• Enter station depths as measured by the pressure sensor into the configuration file	Position	Neither option

After you have made any necessary adjustments to the settings, click on OK to convert the data.

When the recording has been converted, a split window will appear, with the observation data displayed in the top portion of the window, and the position data in the lower portion. Which data are displayed from those recordings depends on the settings you selected for the conversion program.

3. Save the converted data.

Both position and observation recordings (*.rec file format) can be saved in a text format, or in a format for import into other software programs.

Observation recordings = *.rec file
Converted observation recordings saved as text = *.obs file
Converted observation recordings saved for import = *.dbi file

Position recordings = *.rec file
Converted position recording saved as text = *.dat file
Converted position recording saved for import = *.dbi file

Converted recordings saved as text files can be opened within any text reading program such as Notepad or MS Word.

A converted recording saved with a *.dbi extension can be displayed in a chart by importing it into a software program like MS Excel or AREA, a utility program developed by Desert Star Systems. For more information about creating a chart in MS Excel, see page 36. For more information about using AREA, see Appendix C

APPENDIX C

Using the AREA Program

1. **View the perimeter data as a graph.**

   Displaying the position data you recorded during a perimeter swim as a graph will help you visualize the SONAR communications throughout the study site. To do this, you will need to view the converted recording as a *.dbi file.

   On your PC, go to START and right click to get to EXPLORER. Go to the C drive, and choose: PROGRAM FILES DIVETRACKER AREA.EXE. (You may find it easier to create a shortcut on your desktop.)

   When the AREA program opens, you will see a Graph window and a Waypoints window. By moving the Waypoints window to the right, you'll be able to see the Commands window located beneath it. Go to FILE LOAD FILE and select the applicable *.dbi file. (Default location = C:/Program Files/ DiveTracker/Records)

   The plot of recorded points will be displayed on the graph. Some points may appear as "outliers;" these usually indicate noise received during the recording.

   To adjust the size of the graph:

   Go to the WINDOWS drop-down menu and choose DISPLAY PARAMETERS.

   Enter the numbers you choose in the spaces provided for the X and Y Origin.

   Enter the numbers for the desired length of each axis in the X and Y Extent.

   The graph will change as you enter the numbers.

2. **Evaluate the plot for SONAR communication effectiveness.**

   Look for gaps between points. This may coincide with blocked SONAR signals due to large coral heads, other benthic features, or other site anomalies.

3. **Determine the size of your study area.**

   To calculate the area within the perimeter you have recorded (to approximate your study area), use the mouse to trace a line that connects the position recording points.

   Open the *.dbi file of the perimeter recording in the AREA program to display the main plot of your study site. Adjust the size of the graph so that it is large and easy to outline with your mouse. Don't worry about missing the display of outlying points; they are not relevant to the study site.

   In the Commands window, choose DRAW POLY.

   Starting at any point on the perimeter, hold the right mouse button down while you trace the perimeter of your site as defined by the position recording points. Stop when you return to the place where you began.

   Do not overlap the beginning and ending points. If you make a mistake in the tracing, release the mouse button. If incomplete, the perimeter drawing will automatically enclose. Click on UNSET in the Commands window to erase the tracing and you can start over.

When you are satisfied with the perimeter tracing, choose CALCULATE AREA in the Commands window. The size, expressed in square meters, will appear in a message dialog box. Copy this number for use in your metadata.

Clicking on OK will remove the message box. Close the Commands window by clicking on the X at the upper right corner.

4. Generate sample points.

After you have completed the definitive baseline and perimeter survey, you can use the data to create the sample population, randomize that population, and select randomized sets from within that population. During this process, you will create the following files containing Waypoints:

- **Total sample population.** These sample points are numbered sequentially in a serpentine pattern.
- **Randomized sample population.** This file contains the same points as the total population, but they have been renumbered randomly.
- **Subset of randomized sample population.** You select the minimum number of sample points that you will need to analyze a particular study site.
- **Additional subset** from the randomized sample population. You select an additional number of points that may be needed if any of those in the initial subset are found to be in a unacceptable or undesired sample habitat. These “spare” points are also loaded into the diver station to be used if necessary.

To simplify loading Waypoints into the stations, you can include these spare points in the same file as the initial subset. However, the AREA program includes a feature that will re-sequence a set of points into a more efficient path in order to minimize the distance you must swim. To preserve the statistical validity of the random sampling process, you cannot take advantage of this feature unless you keep the spare points in a separate file. If you create a single set of Waypoints that includes the potential spares, you must track to the points in their random sequence until you have found the needed number in acceptable habitat.

The total sample population file is needed only to create the randomized population and does not have to be saved, but the other three files listed above must be saved for future use.

a. Create the total sample population.

On your PC, go to PROGRAM FILES DIVETRACKER AREA.EXE. This will open the Waypoints window and the Commands window directly beneath it.

Open the *.dbi file of the perimeter recording in the AREA program and trace the site perimeter as described in the preceding section.

In the Waypoints window, use the grid divisions to enter the X spacing and Y spacing (i.e., the number of meters) between the sample points. For our videotaping protocol, we are using 10-meter separation on both the X and Y axes.

Choose MAKE to see the total population of possible points within the perimeter of your outlined study area, given the spacing interval you have defined. The points are numbered sequentially in a serpentine pattern, beginning in the lower left.

This file does not have to be saved; it will be modified in the next step to create a randomized sample population.

b. Create a randomized sample population.

Choose SELECT AND RANDOMIZE ALL. The numbers will turn red, and their order will be scrambled.

For reasons of statistical validity, you will only do this scramble once; that is why this file must be saved. Click on SAVE at the bottom of the Waypoints window.

Select the name and location for this *.wpt file. (We use the default location, C:/Program Files/DiveTracker/Config…) Click on SAVE again.

When prompted to confirm whether the points are in meters, click on YES.

The AREA program will confirm that the points are in meters and how many points were saved in the file. Click on OK. Do not close the AREA program.

c. Select a subset of random sample points.

From the randomized sample population, you will select a subset of Waypoints based on the number of samples necessary for the site analysis. For example, this protocol calls for the use of twenty 10-meter transects within the study site, so it will require creating a file containing the coordinates for 20 Waypoints, each of which will indicate the starting point for a 10-meter transect.

Choose SELECT RANGE to bring up the Input Text **Start** Index window.

Enter the number of the first Waypoint (i.e., “1”) in the permutation that you want to find, then click on OK.

The Input Text **End** Index window will open. Enter the number of the last Waypoint you want to include in this sub-sample (i.e., 20), then click on OK.

The subset of the random population will be displayed in red; the other sample points are in black. To conceal the black Waypoints and view only those in the subset, choose ONLY SHOW SELECTED WAYPOINTS.

Click on SAVE at the bottom of the Waypoints window.

In the Save Waypoints window, you will be prompted for a name and location for this *.wpt file. (We use the default location, C:/Program Files/DiveTracker/ Config…). Click on SAVE again.

d. Create a path to connect the points.

The sequence in which the Waypoints appear may not provide the most efficient path for traveling from one point to the next. If you are certain that you will need to use *all* of the sample points in this subset, the Waypoints window offers two ways to create a more efficient path. These alternate paths include the same Waypoints; only the numbers indicating their sequence change.

- If you choose MAKE PATH SERP, the Waypoints will be rearranged in a serpentine pattern beginning in the lower left, progressing to the right.
- If you choose MAKE PATH GREEDY, the Waypoints will be rearranged using the “greedy” algorithm.

In both cases, a message will indicate the distance you would travel if using that particular path. Click on OK to close the message box.

> Remember: To adhere to statistical principles of random sampling, you can only re-sequence points that you will definitely use for sample analysis. This means that if your subset of randomized subset contains 20 Waypoints and you re-sequence them to create a more efficient path, you must use *at least* 20 sampling points in your data analysis. That's because if you re-sequence 20 points and then use only the first 10 in the analysis, those 10 points are no longer considered randomly selected; their selection is biased toward the points at the beginning of the most efficient path.

To use one of the two alternate paths:

Click on MAKE PATH SERP or MAKE PATH GREEDY to display each option. Click OK when the distance is displayed.

Click on SAVE at the bottom of the Waypoints window when the path you want is displayed in it.

In the Save Waypoints window, you will be prompted for a name and location for this *.wpt file. (We use the default location, C:/Program Files/DiveTracker/Config…) Click on SAVE again. Do not close the AREA program.

e. Create a subset of additional sample points.

Study sites inevitably contain some locations that are unsuitable for sampling. For example, in a spur and groove reef zone, a transect may fall in a sand groove. If more than 5 meters of a transect are in sand, the sample point should be discarded. If you must discard any Waypoints from your initial subset because they are in unacceptable locations, you will need additional points in order to sample the desired number of Waypoints.

For example, we select 1-20 as our initial subset of random sample points, then select an additional ten points to be used in case any of the original 20 points are found in unacceptable habitats. If all 20 of the original subset are found to be acceptable, none of the additional points are used. If the videotape for a transect filmed from the initial subset of Waypoints turns out blurry, you cannot replace it with a transect filmed from the additional subset, as this would violate statistical principles of random sampling.

To create this file of additional Waypoints, deselect (un-check) the box next to ONLY SHOW SELECTED WAYPOINTS.

Then repeat the steps under "Select a subset of random sample points" (see page 46). However, the START INDEX and END INDEX numbers will change. For example, if the initial subset of Waypoints had a start index of 1 and an end index of 20, then a subset for 10 alternate Waypoints will have a START INDEX of 21 and an END INDEX of 30.

To display these additional points, choose ONLY SHOW SELECTED WAYPOINTS.

Click on SAVE at the bottom of the Waypoints window.

As explained in step 4 above, you cannot use the MAKE PATH SERP or MAKE PATH GREEDY option to create a more efficient path for a set of points unless you're certain that you'll use all of the points in the set. Since you don't know how many spares you'll need, these additional sample points must remain in the sequence in which they were chosen.

In the Save Waypoints window, you will be prompted for a name and location for this *.wpt file. (We recommend using the default location, C:/Program Files/DiveTracker/Config…) Click on SAVE again.

Close the AREA program.

5. Load the sample points into the diver station.

You will need to load the files containing the initial subset of random sample points and the additional Waypoints into the configuration file so that they can be transferred to the AquaMap stations. The transfer is a two-step process: the *.wpt file is loaded into the configuration file and then the edited configuration file is loaded into the diver station. (See Appendix A for information about editing and downloading the configuration file.) Although the initial subset can be automatically transferred to the configuration file, which prevents transcription errors, the additional subset must be manually entered.

Open DiveTerm and go to FILE EDIT A CONFIGURATION FILE ADVANCED EDIT.

In the Select Configuration File window, open the appropriate *. par file.

Click on NEXT until you get to CONFIG-5 of the configuration file.

Choose EDIT WAYPOINTS near the bottom on the left of the screen. A Waypoints window will be displayed into which you can either manually or automatically enter the coordinates.

Automatic transfer:

To enter the coordinates for the first subset of random sample points automatically, choose LOAD FILE.

In the Save Waypoints window, select the *.wpt file that you created earlier.

Click on OPEN. This will automatically load the coordinates into the configuration file.

> Given the recommended arrangement of the baseline stations (see page 7), the coordinates should be in a *positive X, negative Y* format. This may not be the case if the sample area encompasses both sides of the Y axis, but it is a good thing to check.

Manual entry:

To manually enter the additional set of Waypoint coordinates, you'll need to see them in the *.wpt file. Go to START and choose: PROGRAMS ACCESSORIES NOTEPAD.

Go to the FILE drop-down menu and open the *.wpt file containing the 10 Waypoints you saved.

Before entering the coordinates manually to the diver station, you must convert them to meters. Multiply by 0.3048. Write down the converted values and close the *.wpt file.

Enter the coordinates in the Waypoints window in sequential order, e.g., starting with 21. Click in the appropriate cell or use the tab key to move through the cells.

Check the values and units for Waypoints carefully!

Saving and loading the edited configuration file:

Click on OK in the Waypoints window and in the CONFIG-5 screen.

You will be prompted to save the configuration file, since it has now been modified with the newly saved Waypoint coordinates. Select a name and location. (We use the default location, C:/Program Files/DiveTracker/ Config…) Click on SAVE.

Download the edited configuration file into the diver station and baseline stations (see page 11) so you can track to the Waypoints on each path.

AquaMap uses both Waypoints and Saved Points. Waypoints, which are the points entered into the configuration file, begin with “W”. Saved Points, which are saved through the diver station (typically in the field), begin with ”S”.

6. Check the Waypoint coordinates.

It is a good idea to confirm that the Waypoints have been correctly entered into the diver station before going out in the field. To do this:

Turn on the diver station.

Select the MODE key.

Select “0”/ ↓ four times to select WAYPOINT.

Press ENTER. This will display the View Waypoint screen. Use the function keys to move through each of the Waypoints so you can verify their X , Y coordinates.

If you hit the F3 (DEL) key, you will delete a Waypoint from the list. To reinstall it, you would have to edit the configuration file.

When you are done checking all the Waypoints, select F4/OK to return to the diver status screen.

APPENDIX D

Glossary of Terms

AquaMap™ System: A SONAR-based survey and mapping system used for the mapping, and sample point location/re-location components. The system consists of three principle components, Diver Station, Baseline Station, PC software.

Baseline configuration (physical setup): Use of AquaMap requires that the baseline stations be placed in a rectangular coordinate system. A line starting a Baseline Station 1 and extending through Baseline Station 2 defines the X-axis. Baseline Station 3 *must* be located within 180° clockwise of the X-axis. Ideally, it will be placed at ~ 90°.

(Data): Baseline configuration may also refer to the data entered into the diver station to define the orientation from Baseline Station 1 to Baseline Station 2. The alignment will be used by the diver station to compute and display the bearing to a selected destination. The accuracy of the measurement does not affect the accuracy of surveying. It is therefore usually adequate to use a regular dive compass to determine the orientation of the baseline.

Baseline station: A cylinder housing batteries, electrical circuitry, and SONAR transducer that is deployed near the corners of a rectangular survey site to serve as the reference points for the baseline survey.

Baseline survey: When this command is selected in the diver station, SONAR signals are sent from and received by all stations to "locate" their positions, from which all positions during the subsequent tracking will be referenced.

Configure: To download the configuration file from your PC to the baseline and diver stations, e.g., "The next step is configuring the baseline stations."

Configuration file: A computer file created by the user to defines the operational parameters and working environment during AquaMap use. This is a two-step process of creating/editing a configuration file, and downloading that file. All stations must be configured using the same configuration file.

Connector adapter: AquaMap device with black round wires with brass pins at one end for inserting into the baseline or diver station and a plug for connecting to the data exchange cable on the other end.

Convert™: This utility program is used to transform data recorded in the diver station into a usable format, such as perimeter tracking outlines.

Cross-track error: This display indicates your distance from a direct course between the previous sample point and the next selected point, e.g., <-100 means that the course line is 100 meters/feet to your left; >-100 means it is to your right. When the display reads –000-, you are on the most direct line between the two points. This value is only accurate when you are tracking between sequential points in ascending order, e.g., when you are going from point 10 to 11 or from point 23 to 24. It is not accurate in other sequences, e.g., from point 7 to 9 or point 11 to 10.

DT-test™: A program loaded in the diver station that contains the operational commands for the noise and range test.

Data exchange cables: The flat wires with a fitting that connect the PC serial port either the communication cable of the baseline station or diver station.

Delimiter: A character such as a semicolon that separates two data fields.

DiveTerm: This small program is used to perform several utility functions such as downloading configuration files to stations and downloading tape memory.

DiveTracker: This folder contains the programs Convert and Dive Tracker.

Diver station: This hand-held device computes and displays the SONAR tracking data. The keypad is activated by a magnetic pointer to operate the station.

Diver status screen: This screen is displayed on the diver station to provide dive-related data when using the SmartDive operating system.

File types:

***.dat** AquaMap text file created by converting position recorded data.

***.dbi** AquaMap files that are created after recording data has been run through "Convert." A *.dbi file is loaded into the area program for mapping and plotting purposes.

***.obs** AquaMap text file created by converting observation recorded data.

***.par** AquaMap configuration files that are loaded into the baseline and diver stations.

***.rec** AquaMap files that are created after downloading the recorded fixes during perimeter tracking.

***.wpt** AquaMap waypoint files that are loaded into the Edit Waypoint option of the Edit/Create Configuration file.

***.xls** Spreadsheet format for Microsoft Excel.

Frequency: When using AquaMap, the frequency is expressed in Hertz and should generally be set to the frequency of interest minus 5000 Hz. For example, when doing a noise test, it should be set to the default 29000 Hz (34000-5000=29000).

Gain: This is used in AquaMap to control the amplification of SONAR signals. The four gain settings (0,1,2,3) each represent a doubling in sensitivity, similar to the volume control on a stereo.

Gender adapter: This device is fitted between the serial port of the PC and a cable connector; also known as "male/female connectors".

General navigation screen: Template screen displayed on the diver station and used for navigating to a destination. It displays the distance, bearing and cross-track error to the next waypoint or destination.

Metadata: As used in this protocol, metadata refers to details about the data collection dive and may include depth, time, divers, dive conditions, etc.

Mobile station: Another name for the diver station.

Noise test: This function of the AquaMap system that listens for and then plots (graphically and numerically) the ambient noise on a defined frequency.

Precision navigation screen: Template screen displayed on the diver station and used to fine-tune the diver's position and measure the quality of the position fix. It displays the X:Y position, typical position error, baseline signal indicator, position queue status and time since last fix.

Queue: This is the file of position coordinates that are used to resolve the quality of a position fix (RMS error). It can be set to contain the last two or the last ten coordinates.

RMS error (root mean squared): This typical position error reflects the average distance between each position in the queue and the average position of all position fixes. A large error indicates that positions are widely scattered, and thus there is little data confidence. A small error shows that the positions in the queue are closely tracking each other, thus the data confidence is high.

Range test: This is a test of the AquaMap system's ability to hear a discrete SONAR signal over measured distances.

Readme file: This computer file is created in a word processing application in order to enter metadata.

Record: This command is used in the Precision Navigation Screen to save the position fixes to the diver station memory. To clear the memory, the position fixes must be downloaded to a PC and/or deleted.

SmartDive: A program that operates within the diver station used for tracking.

Standby: When this command issued in the precision navigation screen, none of the position fixes are being saved in the diver station memory.

SONAR transducer cable: A ~6 foot cable with a SONAR transducer on one end and a connector to the diver station on the other. It is attached to the diver station, and calculates the position of the diver (with the diver station) relative to the baseline stations. A float is attached to the hook at the transducer end to keep the transducer floating above the diver.

Threshold: This feature is set in the Advanced Configuration File of the AquaMap system after conducting the noise and range tests.

Transducer: This is the end of the baseline station or SONAR cable from which the pulse is released and received.

Waypoint coordinates: These are pairs of numbers that correspond to the X:Y points used by the AquaMap™ system to locate a position in reference to the baseline stations. They are entered into the diver station as a file, or manually entered into the configuration file.